

The Genus *Ramaria* in Minnesota

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Chapter 1

Introduction

Species of *Ramaria*, a fungal genus with highly-branched fruiting bodies, are found worldwide. They are important decomposers and many form mycorrhizal associations with trees. Despite their size and unique nature, *Ramaria* have been poorly studied in the Midwestern United States. A study of species found in Minnesota and its distinct forest provinces yield data for this group of fungi and contribute toward a taxonomic key that could be used in similar biomes of the Midwest.

1.0 History and Naming of Genus

Branching coralloid (coral-like) fruit bodies are fairly common in the fungal world. Most fungi found with a branching structure were originally placed into the genus *Clavaria* (Coker 1923). The name *Ramaria* originated in 1790 with a specimen named by Holmskjöld but *Ramaria* did not formally achieve genus status until 1933 (Humpert et al. 2001). In order to study how the naming of these unique fungi began, one would have to start in the 1700's with the original drawings and paintings by Schaeffer and others, but thankfully more current works and previous authors have made extensive investigations into the original collections and present us with a clearer view of the path that was taken (Petersen 1975, 1981; Marr and Stuntz 1973, Humpert 2001).

Ramaria was recognized as being distinctly different from *Clavaria* and was believed to belong to Gomphales because of similar spore characteristics. Some still considered the genus to be within Aphyllophorales and when using the nuclear small subunit of ribosomal DNA for genetic analysis, *Ramaria* seemed to remain in that order (Kim and

Jung 2000). Further investigation using more genes in the analysis caused *Ramaria* to be formally moved into Gomphales (Hosaka et al. 2006). The order is composed of toothed fungi, gilled mushrooms, resupinate (crust-like) fungi, and many other types of fruiting bodies but *Ramaria* does share spore characteristics with other members of Gomphales (Hosaka et al. 2006, Villegas et al. 2005).

2.0 Morphological Characters

2.1 Defining Characters for the Genus

The species of *Ramaria* can vary drastically in size, coloration, and life history and have often been confused with other coral fungi because of similar branched fruiting bodies. To separate *Ramaria* species from look-alikes, a set of morphological characteristics are used. Species of *Ramaria* have yellow-brown to rusty-brown spore deposits and the spore wall will react with cotton blue to give a bluish coloration, a reaction termed cyanophilous (Kotlaba and Pouzar 1964). A useful chemical test for the genus is application of 10% ferric sulfate (Fe_2SO_4) to the external surface of the fruiting body (Marr and Stuntz 1973). Though the intensity and speed of the reaction may differ, all members of *Ramaria* will exhibit a 'positive' reaction and the exposed tissue will turn a blue-green color (Exeter et al. 2006, Villegas et al. 2005).

2.2 The Mitic System and Clamp Connections

Hyphal characters are useful for distinguishing among species of *Ramaria*. The most important, according to Corner, is the presence or absence of clamp connections (Corner 1950, 1966, 1970). In *Ramaria* there are species with and without clamps and the

presence or absence is used to differentiate between two otherwise similar looking species.

The hyphae of the basidiocarp and in rhizomorph strands have other qualities for distinguishing species. Corner describes three kinds of hyphae: generative, binding, and skeletal (Corner 1950). According to his description, generative hyphae can be thin to thick walled, have septa and may have clamp connections. Skeletal hyphae are very thick-walled and lack septa and clamp connections. Generally the thickness of the wall is much greater in skeletal hyphae than in thick-walled generative hyphae. It is suggested that skeletal hyphae serve as mechanical support and arise in older tissues (Corner 1950). Skeletal hyphae have been observed arising directly from generative hyphae. In Corner's mitic system, if a specimen has only generative hyphae it is considered monomitic. Dimitic species will have generative and skeletal hyphae and a trimitic species will have all three hyphal types.

Binding hyphae have never been observed in *Ramaria* though species have generative, thick-walled generative and often skeletal hyphae (Corner 1950). This exposes the difficulty with using Corner's mitic system because there is no recognition of a difference between the thin-walled generative and thick-walled generative hyphae, though they are distinctly different and it has been observed that some species will develop only thin-walled hyphae and never thick-walled ones. Some fungal species have both kinds of generative hyphae and lack skeletal hyphae. Cléménçon expanded Corner's mitic system to distinguish between all possible combinations of hyphae (Cléménçon 2004).

In the improved mitic system, a monomitic species has only thin-walled (generative) hyphae. A dimitic species has any combination of two hyphal types and can be further defined as being skeletodimitic, having generative and skeletal hyphae, or psuedodimitic, having generative and thick-walled generative hyphae. The definition of trimitic has been expanded to include any combination of three hyphal types, classifying pseudotrimitic as having generative, supporting, and skeletal hyphae (Clémenton 2004).

A few species of *Ramaria* (example: *R. cystidiophora*) have thin-walled, branching hyphae with lateral spurs that are cyanophilous called acantho-dendroid gleoplerous hyphae (Marr and Stuntz 1973). These distinct hyphae are contextual (not being in the hymenium) and are found in specific *Ramaria* species or varieties.

2.3 Hymenium and Sexual Reproduction

Sexual reproduction occurs with the development of a specialized layer of hyphae called the hymenium, which gives rise to the basidia. Unlike other fruiting body types in Basidiomycota, *Ramaria* does not have a specialized structure for the development of the hymenium. Instead, the hymenium is produced on almost every external surface (Corner 1950). Generally all of the branches and the upper portion of the stipe will produce basidia. This method of hymenial development is typical of highly branched coral fungi (Corner 1950).

The number of sterigmata per basidium can vary between groups of fungi and in the case of coral fungi, can be useful to distinguish between genera. Species within *Ramaria* typically have four sterigmata on each basidium and though the shape and length of the sterigmata can vary, they are normally thin and straight (Corner 1950).

Occasionally three sterigmata are observed. This characteristic can easily separate the genus *Clavulina* from *Ramaria* species, as basidial cells in the former have two inwardly curving sterigmata that resemble curved horns or insect pinchers.

The hymenium of many fungi have sterile cells situated between the basidia called cystidia. There are many kinds of cystidia that are useful for distinguishing between genera and even species. *Ramaria* species lack cystidia (Corner 1950). It is a consistent feature of the genus.

2.4 Basidiospores

The basidiospore characteristics of *Ramaria* are very similar to those of other genera in Gomphales (Villegas et al. 2005). The shape of the spore can vary among species, being ellipsoid, oblong ellipsoid, subfusiform, or some derivation of those typical forms (Snell and Dick 1957). Spore shape, though useful for separating other genera from *Ramaria*, is not particularly helpful for distinguishing between *Ramaria* species.

Basidiospore size, length and width, are often measured in order to determine a size range and average for each species. The range of spore sizes for the genus is large, the width of spores falling anywhere between 2.5 to 6 μm and length being 5 to 16 μm (Christan 2008). Size ranges and averages are important for differentiating between species.

The most useful basidiospore characteristic in *Ramaria* is probably the ornamentation (Marr and Stuntz 1973). There are many terms used to describe the types of ornamentation and even within each term there is variation. The clearest terminology

comes from a discussion of spore characters in Gomphales (Villegas et al. 2005). Spores with no ornamentation are termed smooth. Echinulate spores have spike or spine-like projections and tuberculate-nodulose spores have individual, rounded, and very pronounced warts. The term verrucose refers to warts and lobes, generally rounded, and often connected to form waves or ridges. The last form of ornamentation often found in *Ramaria* is striate, having shallow grooves and lines that form a spiral pattern down the surface of the spore. The degree and size of the warts of a verrucose spore can often be challenging to describe but the ornamentation style for a given species is consistent enough to be useful for distinguishing between macroscopically similar species. An echinulate species will not produce verrucose spores. The consistency of the ornamentation is used in the separation of *Ramaria* species into subgenera (Petersen 1975, 1981).

2.5 Size and Branching

The size and style of branching of *Ramaria* fruiting bodies varies drastically. Though data pertaining to the size and the number of branch tiers is routinely collected for each specimen and used in species descriptions, the age of the fruiting body and the environmental conditions at the time of fruiting can alter these characteristics.

The size of fruiting bodies of a *Ramaria* species is given as a range because of the variation that can occur. Fruiting bodies across the species can range from 2-30 cm tall and 0.4-26 cm wide, displaying everything from very small and slender fruiting bodies to dense, heavy clusters. But the size and general physical appearance of a species should not be dismissed. Each species has a distinct style of fruiting body. A species with a

slender stipe and a small fruiting body will always look markedly different from a species with a thick bulbous stipe and a mass of branches. The general appearance is consistent in *Ramaria* species, sometimes strikingly enough to identify a species immediately in the field.

The genus is often distinguishable from other coral fungi (*Clavaria*, *Clavulina*) by having a more complex branching pattern (Corner 1950). Branching will occur from the stipe in dichotomous or polychotomous fashion, making multiple tiers of branches. Some species are known for having very dense and thick branching patterns. Branching can begin very close to the substrate surface and the location of branching may be indicative of a species.

An additional characteristic is the style of the branch apices. The tip of a branch can have many different forms (rounded, cristate, pyxidate) that may be useful for species identification (Petersen 1988). A coral fungus that looks distinctly ramarioid, *Artomyces pyxidatus* (Auriscalpiaceae, Russulales), has crown-like apices that are distinct enough to be used to instantly distinguish it from a *Ramaria* species in the field.

2.6 Coloration and Bruising Reactions

The coloration of a *Ramaria* fruiting body is an important initial characteristic for identifying to species. It is often the first thing recorded in the field because the color may fade or change after collection. Photographs are extremely helpful for later identification but coloration is often challenging to describe and can be subjective. *Ramaria* species display an amazing array of colors: white, yellow, orange, red, brilliant purple, brown and sometimes green hues. A fruiting body may have one color on the

stipe, a different color on the branches, and yet another color on the branch apices. The coloration of the external (hymenial) tissue may be drastically different from the color of the internal tissue (context). The coloration of the fruiting body is a useful characteristic and is often indicative of the species.

Mycologists use several different color standard books to record fruit body coloration and make descriptions less subjective. Ridgway's Color Standard is most often used but because of the rarity of the book it is challenging to obtain (Ridgway 1912). Petersen (1998) has used the Methuen Handbook of Color (Kornerup and Wanscher 1961) and developed a method to convert between the Methuen colors and Ridgway colors (Petersen 1998). Marr and Stuntz use the Reinhold Color Atlas for their *Ramaria* descriptions (Marr and Stuntz 1973). The National Bureau of Standards published *Color: Universal Language and Dictionary of Names*, which contains references for many different color standards and makes it easy to translate between texts (Kelly and Judd 1976).

Species of this genus often show a color change on bruising. The flesh may change to green (virescent), red brown (rubribrunnescent), brown to yellow brown (brunnescent), or a red wine color (vinescent) (Exeter et al. 2006). Change in color can also occur from age or environmental conditions such as heat or frost (Exeter et al. 2006). Some species are known to have specific bruising reactions (*R. stricta*, *R. formosa*) and the reaction then is a useful character for species identification (Marr and Stuntz 1973).

2.7 Taste and Odor

Observations on the taste and odor of *Ramaria* fruiting bodies tend to be very subjective and are often not used unless the characteristic is consistent for a species. *Ramaria stricta* has two variations; one has no distinct smell (*R. stricta* var. *concolor*) and the other (*R. stricta* var. *stricta*) smells of anise (Marr and Stuntz 1973). The other physical characteristics of the two variations are so similar that the smell can help identify a specimen in the field. The taste and odor can be useful to an individual but are very challenging to describe for the use of others.

2.8 Chemical Tests

Several chemical tests are historically used for differentiating *Ramaria* from other genera of coral fungi and for separating *Ramaria* species. The most useful chemical test is the application of ferric sulfate (FSW) to the external tissue of a fruiting body (Marr and Stuntz 1973). A positive reaction occurs when the tissue turns a green to blue-green color. Many reactions are instant and longer reaction times are considered to be species specific (Exeter et al. 2006). All species of *Ramaria* react positively to ferric sulfate making it an important method of distinguishing *Ramaria* from other coral genera.

Melzer's Reagent is a common chemical test used in mycology and is also used in this genus. Application of Melzer's Reagent to the fruiting body tissue may turn the tissue blue to blue-black, constituting a positive reaction. In the case of *Ramaria*, the hymenium tissue may react positively while the context will not or vice versa. Again, results of this test are consistent for a species.

In *Ramaria of Western Washington*, many different chemical tests were used in addition to Melzer's (Marr and Stuntz 1973). Petersen also uses a similarly long list of chemical reactions in his many monographs and publication of *Ramaria* species (1975, 1981). No one chemical test seems any more helpful in distinguishing between *Ramaria* species than another. However, the results of the test are consistent and may be helpful in addition to other morphological characteristics.

3.0 Life History and Mycorrhizal Associations

Ramaria species perform two distinct and important ecological roles. A fruiting body that develops directly from the soil is called terricolous and these species have symbiotic relationships with a plant, often trees. The hyphae form an external sheath around the roots of a plant, aiding in absorption of water and mineral nutrients. This ectomycorrhizal lifestyle has been confirmed for at least seven *Ramaria* species and it is suggested that all terricolous species are mycorrhizal (Humpert et al. 2001). Determining whether a species is mycorrhizal requires soil coring, examination of tree roots for fungal partners, and genetic sequencing of the fungal tissue (Baier et al. 2006, Scattolind et al. 2008, Tedersoo et al. 2010). The internal transcribed spacer (ITS) of nuclear ribosomal DNA is often used to identify fungal samples from soil cores to species (Nouhra et al. 2004).

Known mycorrhizal *Ramaria* species include *R. aurea*, *R. flava*, *R. formosa*, *R. fumigata*, *R. largentii*, *R. ochraceovirens*, and *R. palmata* and they form mycorrhizae with species of *Abies*, *Cedrus*, *Fagus*, *Larix*, *Picea*, *Pinus*, and *Quercus* (Trappe 1962, Baier et al. 2006, Scattolin et al. 2008). *Ramaria* species have been shown to represent up to 3% of ectomycorrhizal fungi found in a spruce forest (Baier et al. 2006). In a study of

global diversity of ectomycorrhizal fungi, *Ramaria* species appear on all continents except Antarctica (Tedersoo et al. 2010).

Remaining species are saprobic, using decaying material as a nutrition source. Species found on rotting wood or branches are termed lignicolous and may be on either deciduous or coniferous wood. Species found fruiting on leaf or pine needle duff are considered humicolous (Marr and Stuntz 1973, Exeter et al. 2005).

4.0 The subgenera of *Ramaria*

The morphological characters and life history of *Ramaria* species were used to create subgenera, with many divisions, to classify them (Corner 1950, 1970). Four of the subgeneric classifications have been used extensively in the majority of publications (Petersen 1975, 1981, 1998; Marr and Stuntz 1973, Exeter et al. 2006).

Subgenus *Ramaria* contains species that are large, often with a cauliflower appearance, that grow directly from the soil. The hyphae of the fruit body have clamps and the spores have striate ornamentation (Humpert et al. 2001). The species in subgenus *Laeticolora* are also large and terricolous but may or may not have clamps. Ornamentation of spores is either smooth or verrucose. *Laeticolora* and *Ramaria* often have brightly colored fruit bodies (Exeter et al. 2006).

Lentoramaria species also have smooth or verrucose ornamentation but consistently have clamps and are found growing on rotting wood or leaf duff. They develop fruit bodies that are considered small to medium. The subgenus *Echinoramaria* is the most easily distinguishable based on the ornamentation of the spore, being echinulate. Fruit bodies are found on duff, have clamps, and tend to be relatively small (Humpert et al.

2001.) *Lentoramaria* and *Echinoramaria* fruit bodies have neutral colors, browns and creams (Exeter et al. 2006.)

In *Die Gattung Ramaria in Deutschland*, the author ignores the subgenus *Laeticolora* and instead combines those species with some species that were removed from *Echinoramaria*, placing them into a new subgeneric grouping called *Asteroramaria* (Christan 2008). The creation of *Asteroramaria* is based mainly on the presence of star-shaped crystals that appear on rhizomorphic hyphae.

5.0 The Paraphyly of *Ramaria*

The genus *Ramaria* has always been recognized by the previously mentioned morphological characteristics and the very distinct coral-like fruiting shape. But all recent molecular work on the genus has demonstrated that some species of *Ramaria* are not closely related to other *Ramaria* species. When inferring a phylogenetic tree of Gomphales, many other genera in the order appear in clades that lie between clades of *Ramaria* species (Pine et al. 1999, Humpert et al. 2001, Giachini 2004, Giachini et al. 2010). Surprisingly these other genera do not have a coral-like fruiting body. *Gomphus* is the genus that appears most frequently among *Ramaria* species and it has a fruiting body that is distinctly different from the highly branched *Ramarias* (Humpert et al. 2001). As a genus *Ramaria* is consistently shown to lack monophyly. There are definite clades of *Ramaria* species but as a whole the genus must be considered paraphyletic (Humpert et al. 2001).

Some species of subgenus *Echinoramaria* and *Gomphus* that form a monophyletic group have been placed in *Phaeoclavulina* (Giachini 2004). Though the shape of the

fruiting body varies among the species in *Phaeoclavulina*, other morphological characteristics were used as to define the genus and will be discussed below. (Giachini 2004, Giachini et al. 2010).

Though the remaining *Ramaria* species will have to be revised to create monophyletic groupings, some conclusions may be drawn from the phylogenetic trees of Gomphales. In the order, coral fungi (*Ramaria* or *Phaeoclavulina*) form a grade near the root, suggesting that the coral shape was the ancestral form (Humpert et al. 2001, Hosaka et al. 2006, Giachini et al. 2010). The basal species are lignicolous, also suggesting that the ancestor of Gomphales was saprobic (Humpert et al. 2001, Hosaka et al. 2006, Giachini et al. 2010). The coral shape has been shown to be a derived state in the coral genera *Clavaria* and *Pterula* where the ancestral form was resupinate (Dentinger and McLaughlin 2006). The conclusion that the ancestor of Gomphales was coral shaped should be considered carefully because analyses of the group rarely contain more than 20 species of *Ramaria*, less than 10% of the species richness of the genus and incomplete taxon sampling is known to bias phylogenetic inference.

6.0 Distribution of Genus

Ramaria contains 200 to 300 species many of which are found worldwide (Marr and Stuntz 1973, Humpert et al. 2001). Species have been documented for every continent and many from the European countries (Thind 1961, Rattan and Khurana 1978, Christian 2008, Tedersoo et al. 2010).

In the USA, most of the research on the genus has taken place in coastal regions. The Pacific Northwest (Washington, Oregon) has been extensively documented, yielding a

large number of collections and resulting in several published guides specific to *Ramaria* (Marr and Stuntz 1973, Exeter et al. 2006). A specimen database, The Consortium of Pacific Northwest Herbaria, contains 1,445 collections of *Ramaria* species (2007.)

Ronald Petersen from the University of Tennessee-Knoxville massively contributed to the understanding of the genus through collections made in many of the Southeastern states (Tennessee, South Carolina, North Carolina)(Petersen 1971, 1974, 1975, 1976, 1981, 1985). Petersen also collected a great many coral fungi in tropical regions and New Zealand (Petersen 1988). The University of Tennessee-Knoxville fungal herbarium contains 3,057 collections documenting 200 species found in the United States.

The large collections from the coastal states are mainly a reflection of the presence of a mycologist interested in coral fungi. However, the collections do show an enormous amount of species diversity within those states: Washington has 134 documented species, Oregon has 87 species and Tennessee and North Carolina each have over 70 species. Other than the Pacific Northwest and Southeastern states, most of the country is poorly documented for *Ramaria* with some states apparently having none at all (Figure 1).

Ramaria species per state

- - 1-15
- - 16-45
- - 46-75
- - 76-105
- - 106-135

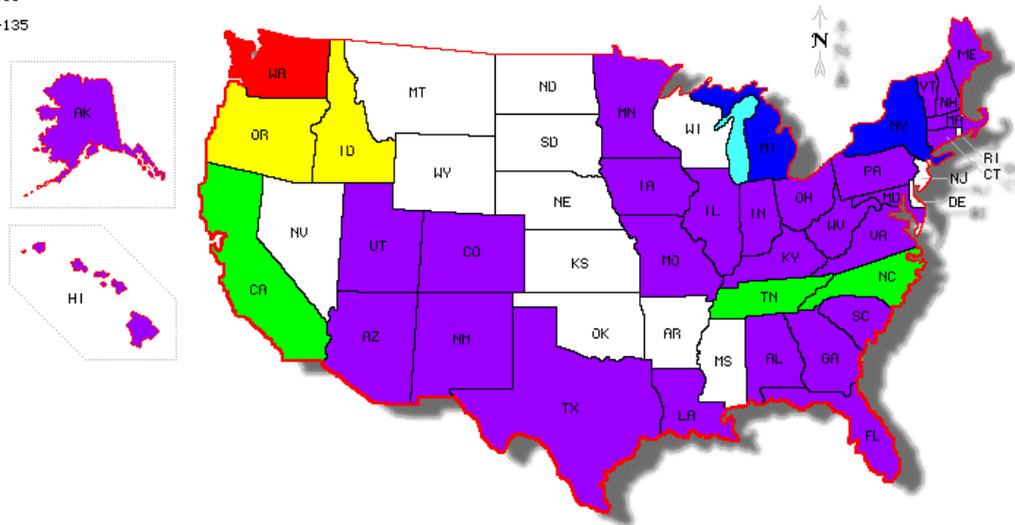


Figure 1: The number of *Ramaria* species per state, collections from the University of Tennessee-Knoxville herbarium, University of Minnesota herbarium, and the Consortium of Pacific Northwest Herbaria (4424 total collections of *Ramaria*)

7.0 Coral Fungi Genera Often Confused With *Ramaria*

7.1 *Clavaria* and *Alloclavaria* (Agaricales, Clavariaceae)

These genera originally contained *Ramaria* species but *Ramaria* was eventually separated based on differences in morphology. Some *Clavaria* species are called coral-like but normally do not branch. They may also be club-shaped or broom-like (Coker 1923). They are monomitic and lack clamp connections, resulting in very fragile fruit bodies. Basidia have 2-4 sterigmata per basidium; basidiospores may be ornamented but produce a white spore print (Corner 1950). Clavarias do not react positively to ferric sulphate. *Alloclavaria* is a genus of club-shaped and coral-like fungi that was discovered to not be very closely related to *Clavaria* and was segregated into the order

Hymenochaetales in a recent restructuring of the family (Dentinger and McLaughlin 2006).

7.2 *Clavulina* (Cantharellales, Clavulinaceae)

Clavulina contains species of highly branched fungi that look very much like *Ramaria*. Microscopic characters easily distinguish the group which has two inwardly curving sterigmata per basidium and smooth subglobose basidiospores without ornamentation (Corner 1950). Another distinct but challenging characteristic is the development of a septum inside the basidium after spores discharge (Corner 1950).

7.3 *Lentaria* (Gomphales, Lentariaceae)

This is the most challenging genus to differentiate from *Ramaria*. Its branching pattern and general shape is practically identical to some *Ramaria* species (Villegas et al. 2005). *Lentaria* species will react positively to ferric sulphate like *Ramaria*. They are able to form clamp connections and skeletal hyphae and the shape of their spores is very similar, if not the same, as *Ramaria* (Corner 1950, Petersen 1967). The important difference is that *Lentaria* species lack ornamentation on the basidiospore and form a white spore print (Corner 1950).

7.4 *Phaeoclavulina* (Gomphales, Gomphaceae)

A group of *Ramaria* subgenus *Echinoramaria* and *Gomphus* species that consistently forms a monophyletic clade has been redesignated *Phaeoclavulina*. (Giachini 2004). These species have monomitic hyphae with clamps, echinulate to verrucose spores, are often lignicolous, and have purple, brown, or orange-red fruit bodies (Giachini 2004). The genus contains both coral-like and pileate fruit body styles. There is no

immediate way to determine if a specimen is in *Phaeoclavulina* because the morphological characters for the genus are also in *Ramaria* species. Sequence data would likely be necessary to place a specimen into *Phaeoclavulina*.

8.0 Diversity of *Ramaria* in Minnesota

8.1 Minnesota Vegetation Provinces

Minnesota is an unusual state because it contains four distinct vegetation provinces: Tallgrass Aspen Parklands, Prairie Parklands, Eastern Broadleaf Forest, and Laurentian Mixed Forest (MN DNR 2003, 2005, 2005). These provinces are differentiated by the native plant communities found there. The two forest provinces may be the most important for *Ramaria* surveys, considering the number of species that are mycorrhizal.

The *Field Guide to the Native Plant Communities of Minnesota* defines the Laurentian Mixed Forest Province as a conifer or mixed hardwood and conifer forest (MN DNR 2003). It is divided into four sections, the first called the Minnesota Drift and Lake Plains (MDL). These forests contain sugar maple, basswood, birch, northern oak, jack pine, and red pine and may include common bog tree species like white cedar. In the Western Superior Uplands (WSU) forest types common tree species are Northern red oak, sugar maple, aspen, and jack pine. The Northern Minnesota and Ontario Peatlands (MOP) are a wet forest with aspens, paper birches, spruces, Balsam firs, and white cedars, and may contain jack or red pines. The final section, referred to as the Northern Superior Uplands (NSU), has white and red pines, and a mix of aspen, birches, Balsam firs, spruces, and sugar maples.

The Eastern Broadleaf Forest Province is divided into two sections of mixed deciduous forests (MN DNR 2005). The Minnesota and Northeast Iowa Morainal (MIM) includes oak and aspen forest common to sandy soils and familiar flood plain trees such as silver maples, cottonwoods, and elms. The Paleozoic Plateau (PPL) contains oak woodlands; wet forests of basswood, sugar maple, black maple, bur oak, and black ash; dry black oak forests; and Mississippi valley woodlands of silver maple, cottonwood, and swamp white oak.

It is likely that *Ramaria* species may be found in all of the biomes of Minnesota. This study focused on the forest biomes because of the dense concentration of oak and pine species that were likely to have mycorrhizal associations with the genus.

8.2 *Ramaria* in Minnesota

With the existence of four distinct biomes in Minnesota and the presence of tree species known to have mycorrhizal associations with *Ramaria* species, it is surprising that the number of *Ramaria* collections and the amount of data on the genus in the state is so limited.

Previous to this work, there were 58 collections of *Ramaria* in the University of Minnesota Herbarium, representing only 13 species. Most collections are not identified to species. These collections were made during general fungal forays and are representative of a limited number of state parks. There has never been a survey where *Ramaria* was the main focus.

Most of the Midwestern states have very few collections of *Ramaria*. The environmental conditions of the Midwest are very different from that of the east and west

coasts, where the majority of research on this genus has taken place. The differences in forest composition and climate between coastal and central states suggest that there may be different fungi establishing mycorrhizal associations with Midwestern trees. The diversity in Michigan is better understood because of the history of dedicated mycologists and there is reason to believe, with environmental conditions being similar in the Midwestern states, that the poorly studied regions are capable of containing a degree of species diversity similar to other parts of the USA.

8.3 Taxonomic Keys

The taxonomic keys specific to coral fungi and *Ramaria* have been published mainly in the Pacific Northwest (Marr and Stuntz 1973, Exeter et al. 2006). There are two distinct seasons for fruiting of *Ramaria*, spring and fall, and the species found there are specific to the season. Marr and Stuntz's key and descriptions are only of fall species (1973). So there is likely some portion of *Ramaria* species that may be documented but do not appear in published work. Petersen published taxonomic keys for the subgenera *Lentoramaria* and *Echinoramaria* based on his collections and described species and also has an unpublished key for the subgenus *Laeticolora* (Petersen 1975, 1981, 1998, personal communication). *Die Gattung Ramaria in Deutschland* contains European species, many of which occur in the USA (Christan 2008).

A study of species found in Minnesota may contribute toward a taxonomic key that could be used in similar biomes of the Midwest.

Chapter 2

Introduction

The genus *Ramaria* produces upright coral mushrooms in summer and fall months all across the USA. These fungi are important decomposers in many forests systems and some are known to form mycorrhizal associations with oak and pine species. Despite their widespread occurrence, the genus has been researched largely on the eastern and western coasts of the USA with moderate collecting in some central states. Most of the Midwestern states have very few documented collections. The University of Minnesota herbarium contains 13 species and many unidentified *Ramaria* specimens, focusing on a limited number of state parks and other collection sites. In 2010, collections of *Ramaria* were made to make an initial assessment of the species diversity in Minnesota, sampling eight state park and Scientific and Natural Areas. Collection sites for this study were in a transect from northwest to southeast, representing two of the major biomes of Minnesota, the conifer and mixed hardwoods of the Laurentian Mixed Forest and the oaks, maples, and basswoods of the Eastern Broadleaf Forest. Gross morphology, microscopic characters and ITS (internal transcribed spacer region) sequences were used to determine species (Nilsson et al. 2008). The survey resulted in 33 new species records for the state with 14 being apparently undescribed species.

2.0 Methods

2.1 Field Collections

Collection sites for the survey included: Afton State Park (SP), Forestville SP, Itasca Wilderness Scientific and Natural Area (SNA), Itasca SP, Lake Alexander Woods

SNA, Nerstrand-Big Woods SP, Pin Oak Prairie SNA, Wild River SP, and Cedar Creek Ecosystem Sciences Reserve (ESR) (Figure 2). Each collection site was sampled at least once each month from June through September. Data gathered in the field included locality and date, habitat and substrate, basidiocarp size, branching type, fruit body color (stipe, branches, apices, context), bruising reactions, odor and taste notes, and chemical test results (FSW, Melzer's, etc.) Photographs were taken in natural light of each fruit body before and after removing from the substrate. All specimens were dried and spore print color was noted. Color was noted as descriptively as possible in the field and then assigned Methuen and Ridgway color names.

2.2 Microscopy

Fruit body tissue was stained with 1% Phloxine and rinsed with 10% potassium hydroxide (KOH) to observe hyphal characteristics (types, number of sterigmata on basidia, presence or absence of clamp connections at basidium base, etc). Basidiospores from the spore print or fruit body tissue were stained with Cotton Blue (in lactic acid) and heated on a hot plate until the stain visibly smoked (Marr and Stuntz 1973). Ornamentation notes and length and width measurements were made under oil immersion lens (1250x). Any special hyphal characteristics (cyanophilous granules, etc) were observed using suggestions and protocols from Marr and Stuntz (1973). Spore measurement were used to calculate special statistical values including the E value (length divided by width), the L^m (median length), the W^m (median width), and the E^m (median length divided by the median width) (Petersen 1975, 1981).

2.3 DNA Extraction, Amplification, Sequencing

Fresh tissue was removed from the fruit body and was placed into 2x CTAB (hexadecyl trimethylammonium bromide: 1 M Tris HCL pH 8, 5 M NaCl, 0.5 M EDTA pH 8, CTAB, double distilled H₂O, 2 β-mercaptoethanol) until DNA extraction could be performed. A modified CTAB extraction protocol for fungal tissue was used that included incubating at 60° C for 50 minutes with vortexing after every 12 minutes and centrifuging and grinding after 24 minutes. Two washes with a mixture of 24 to 1 chloroform: IAA (isoamyl alcohol) were followed by the addition of 3 M NaAc (sodium acetate trihydrate) and absolute EtOH and the tubes were stored at -20° C overnight. After centrifuging, the DNA pellet was washed with cold isopropynol, allowed to dry overnight and finally resolved in 50 µl of sterilized PCR water. Three dilutions of each extraction were made: 1/10, 1/100, 1/1000. The nuclear ribosomal internal transcribed spacer (ITS) region and the adjoining large subunit (LSU) were amplified using ITS5 and LR5 primers (Assembling the Fungal Tree of Life: <http://aftol.org/primers.php>) (Figure 3). The PCR protocol using HotStarTaq Master Mix (QIAGEN HotStarTaq Master Mix Kit) included (i) 15 minutes at 95° C (ii) 1 minutes at 94° C (iii) 30 seconds at 94° C (iv) 45 seconds at 50° C (v) 2 minutes at 72° C (vi) steps 3-5 repeated 30 times (vii) 5 minutes at 72° C (viii) resting at a temperature of 4° C. PCR product was cleaned using either filter columns or ExoSap-IT (USB ExoSAP-IT PCR Product Cleanup, Affymetrix, Inc.) following manufacturer protocol. Sanger QC and sequencing was performed at the BioMedical Genomics Center, University of Minnesota.

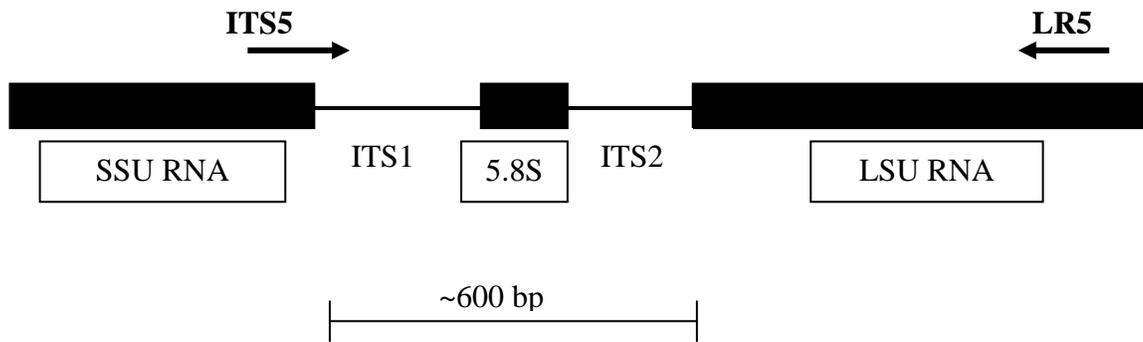


Figure 3: Nuclear ribosomal internal transcribed spacer (ITS) region and the adjoining large subunit (LSU) with primer locations.

2.4 Alignment and Analysis

The forward (ITS) and reverse (LSU) sequences were made contiguous with Sequencher 4.9 (Gene Codes Corporation, Ann Arbor, Michigan) and edited by hand using the sequence chromatogram. Bases that were uninterpretable or ambiguous were left as an ‘N’ to have the most conservative sequence. An alignment of the consensus sequences was made using the ClustalW (Multiple Sequence Alignment tool, Conway Institute UCD, Dublin) function of the sequence alignment editor BioEdit (Tom Hall, Ibis Biosciences, Carlsbad, CA). Phylogenetic analysis was performed using PAUP*4.0b10 (Swofford 2002) to produce a maximum parsimony tree, from the consensus sequences (ITS and LSU), for comparison of the 2010 specimens to each other. Each ITS sequence was put into BLAST (Basic Local Alignment Search Tool, National Center of Biotechnology Information: NCBI) to compare to any available *Ramaria* accessions. GenBank accessions that resulted in close matches to a specimen (maximum identity greater than 97%) were directly aligned and compared using BioEdit.

2.5 Species Determination

Morphological characteristics and sequence matches were used to determine the species for each collection. Taxonomic keys for the Pacific Northwest US (Marr and Stuntz 1973, Exeter et al. 2006), North America (Coker 1923, Petersen 1975, 1981, 1998; Smith et al. 1981), Europe (Christan 2008, Hansen and Knudsen 1997) and worldwide (Corner 1950, 1970) were used. According to Petersen, when determining the species of a collection, the L^m value of the collection should not deviate more or less than 1 μm from the L^m of a species and the E^m value should not deviate by more or less than 0.1 μm from the species (1975). If the values are significantly different, serious consideration is necessary and the specimen is likely not that species.

2.6 Taxonomic Key

The DELTA (DEscription Language for Taxonomy, Dallwitz et al. 1993, 1999) program was used for the creation of taxonomic keys for the Minnesota species of *Ramaria*. A dataset was created using reliable morphological characters (color, clamp connections, hyphal types, spore ornamentation, etc) from each specimen. One key (Appendix 2.1) has species grouped according to *Ramaria* subgeneric classification (*Echinoramaria*, *Ramaria*, *Lentoramaria*, *Laeticolora*) and an additional version contains all of the species in a single key (Appendix 2.2).

3.0 Results

3.1 Collections and Sequencing

A total of 83 collections of coral fungi were made from June 12 to September 29 2010. Multiple collections of *Clavulina cinerea*, *Tremellodendron pallidum*, *Lentaria micheneri*, and *Lentaria byssiseda* were made as well as at least one collection of *Clavulina amethystina*, leaving 59 collections of *Ramaria* species. Six *Ramaria* specimens from previous Minnesota surveys that had full descriptions and photographs were added to the analysis (MCBS147, MCBS153, MCBS266, DJM1507, DJM1628, and DJM1629).

Each *Ramaria* collection was successfully amplified and sequenced; the 1/10 dilution was the most successful. Each specimen's forward (ITS) and reverse (LSU) sequence was made into a consensus sequence with the exception of four collections, AGK008, AGK034, AGK063, and AGK083 in which a read in only one direction was used. The length of the consensus sequence ranged from 1,260 to 2,350 base pairs. Only two of the previous collections (DJM1507, MCBS266) were successfully sequenced from an earlier work. All the ITS sequences were compared to the 419 *Ramaria* accessions representing 66 species in GenBank. The collection sequences matched a variety of species, with maximum identities varying from 88% to 100% (see Table 1). A 97% sequence similarity was considered the threshold for consideration in assigning a species.

3.2 Summary of Species

All collections were identified to species using morphological characteristics and considering matches to GenBank accessions. The 2010 collection contains 36 species

with 14 collections that did not result in any morphological or genetic matches and are likely new species. Four of the species have been previously collected in Minnesota (*R. aurea*, *R. eumorpha*, *R. gracilis*, *R. stricta* var. *concolor*). The total number of *Ramaria* species found in Minnesota as a result of this survey is 45. (For full morphological descriptions and species identification notes see Appendix 1.)

Echinoramaria: The subgenus *Echinoramaria* is the most easily distinguishable based on the ornamentation of the spore, being echinulate. Fruit bodies are found on duff, have clamps, and tend to be relatively small (Humpert et al. 2001.)

***Ramaria argentea* Petersen -AGK 027, AGK 036, AGK 042**: Morphology matches *R. argentea* (Exeter et al. 2006, Christan 2008) including the spore measurements, E^m , and the length of the spores. The sequence did not strongly match any species in GenBank and the specimens are most closely related to AGK 035 (*R. myceliosa*) than any other Minnesota collection.

***Ramaria cf. eumorpha* (P.Karst.) Corner -AGK 008**: The fruiting body was likely young. Specimen had a 98% match with *Ramaria flava*. The specimen does not match that species morphologically and is not closely related to any other species or collections. *R. eumorpha* is a close morphological match and the L^m and E^m are within acceptable range for the species (Exeter et al. 2006).

***Ramaria myceliosa* (Peck) Corner -AGK 035, MCBS153, MCBS266**: The specimen matches the description of *R. myceliosa*, and has appropriate L^m and E^m values (Exeter et al. 2006). The Wild River habitat does contain coniferous trees though none were noted for this collection. The MCBS266 collection has a GenBank match to *R. gracilis* but that species has verrucose ornamentation, unlike the collection.

Ramaria sp. 1 -AGK 012: Very similar to *R. stricta* but having echinulate basidiospore ornamentation. The sequence did not yield a close match in GenBank and the LSU portion of the sequence is too short to be useful. Specimen is old and morphologically closest to *R. argentea* but has a significantly different E^m , L^m , and spore averages (Exeter et al. 2006). AGK 012 does not match any known *Echinoramaria* species in Petersen (1981).

Ramaria sp. 4 -AGK 033: Specimen is very close to *R. myceliosa* in morphology but the E^m and L^m values are significantly different from the species description (Petersen 1981). The sequence is 98% similar to *R. cf. sandaracina* but the specimen does not have the verrucose spores of that species. The three specimens (AGK 033, 037, 038) are most closely related to one another. Also: **AGK 037, AGK 038**

Ramaria sp. 7 -AGK 063: The specimen is not closely related to any other *Ramaria* collection and is morphologically different than the GenBank match of *R. amyloidea*. The spore range of the collection is significantly smaller than any subgenus *Echinoramaria* species and that of AGK 012.

Laeticolora: The species in subgenus *Laeticolora* contains large, often colorful, terricolous fruit bodies that may or may not have clamps. Ornamentation of spores is either smooth or verrucose.

***Ramaria acrisiccescens* Marr and Stuntz - DJM1629**: *R. acrisiccescens* is the best morphological fit for the specimen. The spore range and fruit body characteristics match the description of *R. acrisiccescens*.

Ramaria cf. acrisiccescens Marr and Stuntz -**AGK 077**: The morphology of the specimen best matches *R. acrisiccescens* but sequence does not match or place the specimen close to the species. The spores of the collection tend to be wider but every other character of the specimen is appropriate for this species.

Ramaria aurea (Schaeff.: Fr.) Quél. - **AGK 025**: The specimen sequence yields a GenBank match of 97% to *R. aurantiisiccescens* among others. Morphological data matches *R. aurea* (Petersen 1974). The description of the species in Corner (1950) claims that this species is clamped but all other sources list *R. aurea* as clampless (Smith et al. 1981, Hansen and Knudsen 1997, Christan 2008).

Ramaria cf. celerivirescens Marr and Stuntz -**AGK 072**: The specimen matches *R. celerivirescens*, having appropriate spore size and coloration. The habitat for the species is coniferous while the specimen was collected in deciduous woods only. The diagnostic characteristic of a brown band of contextual hyphae was not noted in the specimen and the specimen would need to be recollected and examined when fresh to determine for certain if the species description matches.

Ramaria cyaneigranosa - **DJM1628**: Morphology is closest to *R. cyaneigranosa* var. *cyaneigranosa* but the specimen is a lighter pink coloration than is reported for this species.

Ramaria flavigelatinosa Marr and Stuntz - **AGK 028, AGK 083**: *R. flavigelatinosa* is a morphologically match to AGK 028 with exception that the species is reported to occur in a coniferous habitat (Marr and Stuntz 1973, Exeter et al. 2006). Genetically the specimen is most closely related to AGK 083 (than any other Minnesota

collection) and is likely the same species but there is no significant match to any GenBank accession.

***Ramaria flavigelationosa* cf. var. *carnisalmonea* Marr and Stuntz - AGK 075:**

The specimen closely matches the description of *R. flavigelationosa*. Variety *carnisalmonea* has the appropriate form, orange pinkish coloration to the branches, and correctly sized spores. However, the specimen was collected in deciduous woods and the branch context coloration was not observed for the collection.

***Ramaria flavobrunnescens* var. *aromatica* Marr and Stuntz - AGK 059:**

The specimen matches *R. flavobrunnescens* var. *aromatica*, with the exception of not being collected in a coniferous habitat, and the sequence has a 98% match with *R. flavobrunnescens* var. *aromatica*.

***Ramaria foetida* Petersen - AGK 058:**

The specimen description best matches *R. foetida*, having appropriate spore values, habitat, and the diagnostic unpleasant smell (Exeter et al. 2006). The sequence of the specimen has a GenBank match to *R. apiculata* but has significant morphological differences including unclamped hyphae.

***Ramaria* cf. *longispora* - DJM1507:**

R. longispora is the closest morphological match to the specimen, though the spore average of the specimen is smaller than in the species description. The collection is morphologically distinct from the GenBank match of *R. rubella*.

***Ramaria pusilla* Corner - AGK 057:**

The specimen is not genetically similar to any other collection but does result in a match to *R. stricta* on GenBank. The morphology matches the description of *R. pusilla*, having distinctly different spore ornamentation than *R. stricta*. AGK 057 lacks the vinescent bruising reaction noted for the species by Corner

(1950) and Smith et al. (1981) but the description of the type specimen, viewed by Marr and Stuntz (1973), does not include any mention of a vinescent bruising reaction.

***Ramaria cf. rasilisporoides* Exeter - AGK 069:** The specimen matches the description of *R. rasilisporoides* including the diagnostic characteristic of having a deeply rooting base. AGK 069 was found in deciduous woods, not in coniferous woods like *R. rasilisporoides*. The species is reported only from Oregon and there are very few collections but AGK 069 is convincingly similar to the description of this species.

***Ramaria cf. rubiginosa* Marr and Stuntz - AGK 056I:** Though the specimen lacks vinescent bruising and was collected in a deciduous habitat, the morphology best matches *R. rubiginosa* (Exeter et al. 2006). The bruising reaction of the fruit body is a diagnostic character of the species.

***Ramaria rubricarnata var. pallida* Petersen and Scates - AGK 078, AGK 079:** The morphology of the specimen and the coloration of the fruit body match *R. rubricarnata var. pallida*. The specimen does have slightly smaller spores than those reported for this species and is found in a deciduous, not coniferous habitat.

***Ramaria sandaracina* Marr and Stuntz - AGK 082:** The specimen matches *R. sandaracina*. *R. sandaracina var. euosma* is the closest in color and shape while *R. sandaracina var. sandaracina* has a more appropriate spore range. The species is found in coniferous woods and the specimen was collected in deciduous woods.

***Ramaria sp. 9* -AGK 067, AGK 070:** The specimen does not match any species in subgenus *Laeticolora* (Petersen 1998 unpublished, Exeter et al. 2006). The color of the stipe, branches, and apices and the size of the spores make the collection unique. AGK

070 is likely an immature fruit body of the same species, having similar spore size but being a more honey yellow color.

Ramaria sp. 10 - AGK 068: The specimen is morphologically similar to AGK 067 (*R. sp. 9*) with the exception of a slight pink coloration to the stipe and branches. The sequence does match *R. stricta* in GenBank and appears to not be closely related to AGK 067. AGK 068 is not close to *R. stricta* in either morphology or substrate. There is no species match in subgenus *Laeticolora* and the specimen is genetically different enough from AGK 067 to consider it a separate undescribed species.

Ramaria sp. 11 -AGK 071: AGK 071 is not closely related to any other collection or GenBank species and does not match any subgenus *Laeticolora* species. The color of the fruit body and the small spore size make the collection unique.

Lentoramaria: *Lentoramaria* species also have smooth or verrucose ornamentation but consistently have clamps and are found growing on rotting wood or leaf duff. They develop fruit bodies that are considered small to medium.

***Ramaria cf. gracilis* (Pers.) Quél. - AGK 016, AGK 017, AGK 018, AGK 024, AGK 032, AGK 061, MCBS147**: AGK 016 morphologically matches *R. gracilis* but is not genetically close to that species and was found in a deciduous, not coniferous, habitat as *R.gracilis* is. The sequence has a match of 96% with *R. stricta*.

***Ramaria rubella* (Schaeff.) Petersen - AGK 062**: The specimen morphologically matches the description for *R. rubella* but does not appear to be closely genetically related to *R. rubella* f. *rubella*.

Ramaria rubella f. rubella (Schaeff.) Petersen - **AGK 049**: The specimen matches *R. rubella f. rubella* though the rhizomorphs of the collection do not turn pink in KOH as in the species description (Petersen 1975, Exeter et al. 2006). The test was performed on dried material and that may have affected the test result. Though showing a 98% match to *R. abietina* in GenBank, the collection is morphologically different and shows no virescent bruising indicative of the species.

Ramaria stricta var. concolor Corner - **AGK 010, AGK 011, AGK 013, AGK 014, AGK 015, AGK 019, AGK 052**: Specimen had a 98% match with *Ramaria stricta*. Though the species is *R. stricta var. concolor* based on overall morphology, the specimens seems most closely related to *R. rainieriensis* genetically, not other GenBank *R. stricta* accessions. Genetic differences may be because of variety differences, which are not clarified on GenBank. There seem to be three distinct *R. stricta* sequence types in Genbank, one of which may not be *R. stricta*.

Ramaria stricta var. stricta (Pers.) Quél. - **AGK 044, AGK 045, AGK 046**: The specimen description matches *R. stricta var. stricta*. The distinct anise smell is the best method for distinguishing this species from *R. stricta var. concolor*. Specimens AGK 044, 045, 046 are most closely related to one another morphologically and genetically and are not closely related to *R. stricta var. concolor* specimens.

Ramaria sp. 5 - **AGK 051, AGK 080**: The specimen does not match any known species of subgenus *Lentoramaria* because the collection has a spore range that is significantly smaller than any published species (Petersen 1975). *Ramaria sp. 5* did result in a GenBank match to *Phaeoclavulina zippelii* but is morphologically distinct and is a lignicolous species rather than terricolous.

Ramaria sp. 6 - AGK 053: The specimen is morphologically closest to *R. suecica* but has an average spore size that does not fall within *R. suecica*'s range. The sequence of the collection matches *R. circinans* var. *anceps* in GenBank but is morphologically distinct.

Ramaria sp. 8 - AGK 066: AGK 066 does not match any known subgenus *Lentoramaria* species. Morphologically the specimen would be closest to *R. concolor* and *R. stricta*, the former having larger spores and a significantly different E^m value; the latter being also morphologically different. There are a reasonable number of *R. stricta* sequences in GenBank that should have resulted in a match for the specimen but AGK 066 is not closely related any sequence from the species. There is a GenBank match to *R. abietina* but again the morphology of this collection is not similar to that virescent bruising species.

Ramaria sp. 12 - AGK 073: Specimens were placed into a closed plastic container for approximately two hours during the collection trip. A drastic brown-purple color change may be the result of bruising but every surface, including internal branch axils, changed. It is likely a reaction to a humid and warm condition inside the container. It should be noted that no other collections of *Ramaria* were affected by being in similar conditions. The specimen does not key to any current species and the sequence matches only to *R. abietina*, which shares no morphological similarities with the collection. The combination of colorations of the stipe, branches, and apices, as well as the overall color shift from yellow when young to purple-brown when old, makes the specimens distinctly different than anything in subgenus *Lentoramaria* or *Laeticolora*.

Ramaria sp. 13 - AGK 076: In a small area, hundreds of fruiting bodies existed in trails around the base of white pines. The specimens do not match any current species of *Ramaria* in subgenus *Lentoramaria* or *Laeticolora* and the sequence does not result in any convincing match. The tuberculate-nodulose ornamentation of the spores makes the specimen unique among the other AGK collections. The coloration of the fruit bodies may be lighter in younger and fresher samples but the overall description would not be altered.

Ramaria sp. 14 - AGK 081: There is no subgenus *Lentoramaria* or *Laeticolora* species that matches the specimen, the small spore size of the collection making it unique (Corner 1950, Marr & Stuntz 1973, Petersen 1975, Hansen et al. 1997, Exeter et al. 2006).

Ramaria: Subgenus *Ramaria* contains species that are large, often with a cauliflower appearance, that grow directly from the soil. The hyphae of the fruit body have clamps and the spores have striate ornamentation (Humpert et al. 2001).

Ramaria sp. 2 - AGK 020: This specimen is not morphologically close to any described species with a purple tint to the branches. Specimen is close to AGK 023 and AGK 064 (*R. sp 3*) and *R. cystidiophora*. The morphology of this specimen does not match *R. cystidiophora*, mainly because of the absence of purplish pink coloration in that species.

Ramaria sp. 3 -AGK 023, AGK 064: The specimen is morphologically close to *R. rubripermanens* but the spores sizes of this collection are on average smaller and do not fit within the range for this species. The specimen is not genetically closely related to

R. rubripermanens but is close to AGK 020 (*R. sp. 2*) and *R. cystidiophora*. Though both AGK 020 and AGK 023 look similar and seem closely related, the spore measurements of the two collections are different enough to suggest they are two distinct species. The morphology of this specimen does not match *R. cystidiophora* (this collection has striate spores and a different overall appearance).

3.3 Distribution Patterns and Habitat

The species collected in Minnesota reflect five distinct distribution patterns: North America and Europe, Pacific Northwest, Pacific Northwest and Europe, North America, and one species that is found in Europe and North America but not in Washington or Oregon (Table 2). The collection of PNW or PNW and European species in Minnesota represent new range records and change the known distribution patterns.

The majority of collected species, Pacific Northwestern specifically, are recorded as being found in coniferous woods with a few appearing in both coniferous and deciduous forests. Thirteen of the species recorded in coniferous habitats were collected in deciduous habitats in this study (Table 2).

Table 1: Minnesota *Ramaria* species from 2010 collection with location, date, and GenBank match.

Species	Collection no.	Location	Date	ITS match
<i>R. acrisiccescens</i>	DJM1629	Itasca State Park, MN	17-Aug-10	n/a
<i>R. cf. acrisiccescens</i>	AGK 077	Itasca State Park, MN	18-Aug-10	94% <i>R. largentii</i> EU652383.1
<i>R. argentea</i>	AGK 027	U of M Cedar Creek Research Area, MN	16-Jul-10	95% <i>R.cf. formosa</i> EU486433.1
	AGK 036	Wild River State Park, MN	24-Jul-10	96% <i>R. stricta</i> AF347098.1
	AGK 042	"	"	"
<i>R. aurea</i>	AGK 025	Nerstrand-Big Woods State Park, MN	12-Jul-10	97% <i>R.aurantiisiccescens</i> EU669422.1
<i>R. cf. celerivirescens</i>	AGK 072	Nerstrand-Big Woods State Park, MN	13-Aug-10	96% <i>R. testaceoflava</i> AY586708.1
<i>R. cyaneigranosa</i>	DJM1628	Itasca State Park, MN	17-Aug-09	n/a
<i>R. cf. eumorpha</i>	AGK 008	Vermillion River Complex, BioBlitz at UMore Park, MN	12-Jun-10	98% <i>R. flava</i> AJ408364.1
<i>R. flavigelationsa</i>	AGK 028	Afton State Park, MN	17-Jul-10	96% <i>R. araiospora</i> EU669296.1
	AGK 083	"	29-Sep-10	"
<i>R. flavigelationsa</i> cf. var. <i>carnisalmonea</i>	AGK 075	U of M Cedar Creek Research Area, MN	15-Aug-10	95% <i>R. araiospora</i> EU669296.1
<i>R. flavobrunnescens</i> var. <i>aromatica</i>	AGK 059	Lake Alexander Woods State Natural Area, MN	28-Jul-10	98% <i>R.flavobrunnescens</i> var. <i>aromatica</i> AF213083.1
<i>R. foetida</i>	AGK 058	Lake Alexander Woods State Natural Area, MN	28-Jul-10	100% <i>R. apiculata</i> AJ408385.1
<i>R. cf. gracilis</i>	AGK 016	Pin Oak Prairie Scientific and Natural Area, MN	10-Jul-10	96% <i>R. stricta</i> AF213118.1
	AGK 017	"	"	"
	AGK 018	"	"	"
	AGK 024	Forestville State Park, MN	11-Jul-10	"
	AGK 032	Wild River State Park, MN	24-Jul-10	"

	AGK 061	Pin Oak Prairie Scientific and Natural Area, MN	7-Aug-10	"
	MCBS147	Camden State Park, top of Dakota Valley Trail, MN	29-Aug-07	n/a
<i>R. cf. longispora</i>	DJM1507	Mille Lacs Kathio State Park, MN	17-Sep-08	97% <i>R. rubella</i> AY854078.1
<i>R. myceliosa</i>	AGK 035	Wild River State Park, MN	24-Jul-10	96% <i>R. decurrens</i> AF442099.1
	MCBS153	Camden State Park, top of the Dakota Valley Trail, MN	29-Aug-07	n/a
	MCBS266	Paul Bunyan State Forest, MN	28-Sep-07	100% <i>R. gracilis</i> AJ408378.1
<i>R. pusilla</i>	AGK 057	Lake Alexander Woods State Natural Area, MN	28-Jul-10	100% <i>R. stricta</i> AF347098.1
<i>R. rasilisporoides</i>	AGK 069	Nerstrand-Big Woods State Park, MN	13-Aug-10	95% <i>R. rubrievanescens</i> AF213061.1
<i>R. rubella</i>	AGK 062	Pin Oak Prairie Scientific and Natural Area, MN	7-Aug-10	96% <i>R. stricta</i> AF213118.1
<i>R. rubella</i> f. <i>rubella</i>	AGK 049	Itasca State Park, MN	26-Jul-10	98% <i>R. abietina</i> FJ627035.1
<i>R. cf. rubiginosa</i>	AGK 056I	Lake Alexander Woods State Natural Area, MN	26-Jul-10	95% <i>R. araiospora</i> EU669296.1
<i>R. rubricarnata</i> var. <i>pallida</i>	AGK 078	Itasca State Park, MN	18-Aug-10	94% <i>R. botrytis</i> var. <i>botrytis</i> AY574699.1
	AGK 079	"	"	"
<i>R. sandaracina</i>	AGK 082	Jay Cooke State Park, MN	12-Sep-10	91% <i>R. fennica</i> AF213080.1
<i>R. stricta</i> var. <i>concolor</i>	AGK 013	Pin Oak Prairie Scientific and Natural Area, MN	10-Jul-10	"
	AGK 014	"	"	"
	AGK 015	"	"	"
	AGK 019	"	"	"
	AGK 052	Itasca State Park, MN	26-Jul-10	"
<i>R. stricta</i> var. <i>stricta</i>	AGK 044	Itasca State Park, MN	26-Jul-10	98% <i>R. stricta</i> FJ644512.1
	AGK 045	"	"	"
	AGK 046	"	"	"
<i>R. sp. 1</i>	AGK 012	Pin Oak Prairie Scientific and Natural Area, MN	10-Jul-10	n/a
<i>R. sp. 2</i>	AGK 020	Forestville State Park, MN	10-Jul-10	96% <i>R. botrytis</i> var. <i>botrytis</i> AY574699.1

<i>R. sp. 3</i>	AGK 023	Forestville State Park, MN	10-Jul-10	94% <i>R.botrytis</i> var. <i>botrytis</i> AY574698.1
	AGK 064	"	8-Aug-10	"
<i>R. sp. 4</i>	AGK 033	Wild River State Park, MN	24-Jul-10	98% <i>R.cf. sandaracina</i> EU669348.1
	AGK 037	"	"	"
	AGK 038	"	"	"
<i>R. sp. 5</i>	AGK 051	Itasca State Park, MN	26-Jul-10	100% <i>Phaeoclavulina</i> <i>zippelii</i> AF213111.1
	AGK 080	"	20-Aug-10	"
<i>R. sp. 6</i>	AGK 053	Itasca State Park, MN	26-Jul-10	99% <i>R. circinans</i> var. <i>anceps</i> AY574711.1
<i>R. sp. 7</i>	AGK 063	Pin Oak Prairie Scientific and Natural Area, MN	07-Aug-10	98% <i>R. amyloidea</i> EU837196.1
<i>R. sp. 8</i>	AGK 066	Forestville State Park, MN	8-Aug-10	97% <i>R. abietina</i> FJ627035.1
<i>R. sp. 9</i>	AGK 067	Nerstrand –Big Woods State Park, MN	13-Aug-10	93% <i>R. sandaracina</i> AY102860.1
	AGK 070	"	"	n/a
<i>R. sp. 10</i>	AGK 068	Nerstrand-Big Woods State Park, MN	13-Aug-10	100% <i>R. stricta</i> AF347098.1
<i>R. sp. 11</i>	AGK 071	Nerstrand-Big Woods State Park, MN	13-Aug-10	93% <i>R.cf.sandaracina</i> EF530928.1
<i>R. sp. 12</i>	AGK 073	U of M Cedar Creek Research Area, MN	15-Aug-10	97% <i>R. abietina</i> FJ627035.1
<i>R. sp. 13</i>	AGK 076	U of M Cedar Creek Research Area, MN	15-Aug-10	95% <i>R. araiospora</i> EU669246.1
<i>R. sp. 14</i>	AGK 081	Itasca State Park, MN	20-Aug-10	95% <i>R. cystidiophora</i> DQ384590.1

Table 2: Distribution and habitat of collected species: Habitat: c=coniferous, d=deciduous. New deciduous habitat records= **D**.

Pacific Northwest	Habitat		
<i>R. acrisiccescens</i>	c+ D		
<i>R. celerivirescens</i>	c+ D		
<i>R. cyaneigranosa</i>	c		
<i>R. flavigelatinosa</i>	c+ D		
<i>R. flavigelatinosa</i> var. <i>carnisalmonea</i>	c+ D	North America and Europe	Habitat
<i>R. flavobrunnescens</i> var. <i>aromatica</i>	c+ D	<i>R. eumorpha</i>	c+ D
<i>R. foetida</i>	c	<i>R. gracilis</i>	c+ D
<i>R. longispora</i>	c+ D	<i>R. myceliosa</i>	c+d
<i>R. rasilisporoides</i>	c+ D	<i>R. rubella</i>	c
<i>R. rubiginosa</i>	c+ D	<i>R. stricta</i>	c+d
<i>R. rubricarnata</i> var. <i>pallida</i>	c+ D	North America	
<i>R. sandaracina</i>	c+ D	<i>R. pusilla</i>	c+d
PNW and Europe		Europe and NA, except WA/OR	
<i>R. argentea</i>	c+ D	<i>R. aurea</i>	d

4.0 Discussion

4.1 Field Collections and Morphology

The morphological characteristics taken at the time of collecting are very important for the determination of species, especially color and bruising notes. Several species and varieties rely on the color of the branch context or bruising reactions and without notes on such characteristics, it can be challenging to determine variety. It is best to perform chemical tests on fresh material as dried material seems to not yield diagnostic color changes (Exeter et al. 2006, Marr and Stuntz 1973). Several species in this survey that are considered new rely on fruit body color as a diagnostic character.

Basidiospore measurements and statistics were extremely useful in determining species. Petersen's guidelines concerning the L^m and E^m values of a species were often

relied upon (in addition to other morphological characteristics) to resolve a species determination (Petersen 1975, 1981).

4.2 Genetics

All the genetic material that was extracted was amplified relatively easily, which was likely a result of placing tissue from fresh fruit bodies immediately into CTAB for storage until the time of extraction. The primers used for amplification were chosen to obtain the variable ITS region and a portion of the conserved LSU but there were a few occasions in which the sequences were too short to create a continuous sequence.

Overall, the amount of coverage received when using BLAST was poor.

The number of *Ramaria* species present in GenBank proved to be the hindrance of using ITS for species level determination. Though there are 66 species in GenBank, they represent only 22% to 33% of the actual number of *Ramaria* species reputed to exist worldwide. (There are 200 species known for the USA alone). The database proved to be most helpful in eliminating a species from consideration rather than species confirmation. For example: AGK066 is morphologically similar to *R. stricta* but has been labeled an undescribed species based on the fact that the sequence is not closely related to that species.

On occasion, the *Ramaria* accessions in GenBank were called into question. There are at least three distinct groups of sequences labeled *Ramaria stricta*, two of which can be explained by the accepted *stricta* varieties. The third group is genetically different enough to suggest that the sample may be mislabeled. This suggestion is further supported by the fact that there are two collections in this survey that are macroscopically similar to *R. stricta* and could easily be mistakenly assigned to that species, but

microscopic examination shows that the spores are echinulate rather than verrucose. Because of the common occurrence of the species, it is likely that many specimens are never microscopically examined.

It is challenging to comment on the validity of ITS for species level determination of *Ramaria* because of the limited sampling of the genus as a whole.

4.3 Taxonomic Keys and Distribution

The taxonomic keys that exist for *Ramaria* reflect where the genus has been most studied and though they contain hundreds of species, the results of this one year survey show that there are many species in the Midwestern USA that appear to be undescribed. Most of the identified collections show both range and habitat expansion. The diversity of the vegetation in Minnesota is likely what contributes to the diversity of collected species but there is no taxonomic key that truly addresses the species that have been found in the state.

Some morphological characters are more reliable than others in the production of a taxonomic key. The DELTA program can easily create a conventional key based on a dataset of morphological characters but it does not seem possible to weigh the characters of the dataset to place more emphasis on reliable characteristics like substrate, spore ornamentation, fruit body color, hyphae, and clamp connections. The KEY program often chooses characters that are not normally diagnostic (basal tomentum, odor, taste) to be critical key steps. (If DELTA is used to create an *interactive* key, weights can be altered.) As a result, it seemed most appropriate to divide the species into the subgenera (Appendix 2.1) to force separation by some diagnostic characters. Therefore, the first key is for *Ramaria* subgenera and there are four separate keys, one for each subgenus. The

character list is the same for each key. The key produced with all the species can also be used but is likely less functional (Appendix 2.2). Though the DELTA program is simple to use and can produce a conventional key easily, a great deal of consideration needs to be made in the organization of characters in the dataset in order to produce a useful key with descriptive key steps.

5.0 Conclusion

The 2010 survey of *Ramaria* in Minnesota resulted in a total of 33 new species records, 14 of which appear to be undescribed, bringing the total number to 45 species in the state. The known species show both range and habitat expansion. The ITS database in GenBank is very incomplete and a limited number of specimens matched a known species. The results and coverage of the survey suggest that the diversity of the genus in the state has yet to be fully explored.

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Appendix

Appendix 1: Collection species descriptions

Color notes: The color descriptions of each species contain three versions, the first being the initial field notes, in brackets is the number-letter designation and name from the Methuen color standard, and in parentheses is the Ridgway color equivalent. For example: field color [Methuen color (Ridgway color)]. If there is no specific color name or equivalent name, a dash will appear instead.

Subgenus *Echinoramaria*

AGK 027- *Ramaria argentea* R.H. Petersen

(Plate I, Figure 1)

GenBank accession: JQ408227

Basidiocarp: Habitat - - on rotting log and duff in deciduous woods (maple, basswood) in bog area

Color- -light cream tan [4A6 maize yellow (light orange-yellow), 4A7 buttercup yellow (apricot yellow, light cadmium)]branches, apices, and stipe, cream [3A3 pale yellow (cream color)] context.

Taste- -bitter

Odor- -not distinct

Form- - basidiocarp medium, 4.5 cm tall by 3.5 cm wide by 1 cm deep, branches 0.2 cm wide, stipe base 0.3 cm wide. Polychotomous branching, flexible rubbery, branches may be leggy from developing under dead wood, apices acute, tri-pointed. Slight white basal tomentum up to point of branches. Rhizomorphs cling to duff.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: 5.14-6.32 x 3.16 (-4.74), average: 5.68 x 3.36, E value: 1.69, Lm: 5.53, Wm: 3.16, Em: 1.75, oval with verrucose ornamentation, having spines longer than 0.6 but less than 1.2 μm .

Basidia: Four sterigmata, clamped

Hyphae: Generative hyphae with clamps

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 027	Cedar Creek ESR, MN	16 July 2010
AGK 036	Wild River State Park, MN	24 July 2010
AGK 042	“	24 July 2010

Distribution: USA- CA, CO, ID, NM, UT; Europe- Sweden

Discussion: Morphology matches *R. argentea* (Exeter 2006, Christan 2008) including the spore measurements, E^m value, and the length of the spores. The ITS sequence does not strongly match any species in GenBank and the specimen is most closely related to AGK 035.

AGK 008--*Ramaria cf. eumorpha* (P.Karst.) Corner

Basidiocarp:

Habitat -- on soil in deciduous woods (aspen, elm, oak, birch).

Color--yellow brown branches and apices, cream white context .

Taste-- N/A Odor—N/A

Form—basidiocarp small (young?), less than 2 cm tall and stipe 0.2 cm wide.Branches slightly flattened and only near top of fruit body, apices cuspid. Stipe single with white basal tomentum.

Macrochemical Reactions:

Bruising reaction: N/A

Ferric Sulphate: positive.

Melzer's: nonamyloid.

Gum Guaiac: positive ?

Microscopic Structures:

Spore print--N/A

Spore: (at 1250 μm) range: (5.53-) 5.93-6.32(-7.11) x (2.77-) 3.16-3.56, average: 6.12 x 3.06, E value: 2, L^m: 6.32, W^m: 3.16, E^m: 2, elliptic-fusiform with echinulate ornamentation, large oil droplets.

Basidia: Four sterigmata, often three; slightly incurved; no obvious clamp connections.

Hyphae: generative with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 008	Vermillion River Complex, BioBlitz at UMore Park, MN	12 June 2010

Distribution: USA- CA, ID, IN, MA, MI, MN, NC, NY, OR, TN, WA; Canada; Europe- England, Scandinavia

Discussion: The fruiting body was likely young. Specimen had a 98% match with *Ramaria flava* and *R. aurea* with very low (30%) coverage. The specimen is neither of those species and is not closely related to any other species or collections. *R. eumorpha* is a close morphological match and the L^m and E^m are within acceptable range for the species. (according to Exeter 2006).

>AGK008ITS

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CGCTGGAAGGCTGACTGCGGAGGACATTACAGAATGTAATGGGACGGTTG
TAGCTGGCCCCCTCGGGGAGCAAAGTGCACGCCGTCTCTACTTCTAATCC
CCATACACACTTGTGCACCTGTGGGTGAGCCTCCCATGAGGAGCCGTCCC
GTGTAACCTCTTTGGTCCTTCGGGGCTGAAGGGGGGGCGGGACTGAGGCT
CGCACCATTGATTCCATCACTTATGCCTGTCTATATGCATGTATTTGGGT
AATCGGAAATTGTAATAACAACCTTTCAACAACGGATCTCTTGGTTTTTCGA
TCGATGAAGGACGCCGCGAAAGTGCGAAACGTAATGTGAATTGCAGAATT
CAGTGAATCATCGAATCTTTGAACGCATCTTGCGCTCCTTGGTATTCCGA
GGAGCATGCCTGTTTGAGTGTCTTGAACATGCTCGACCCCTTGATGTGTT
TTTCATGTCAATGGGAGTCGGATTTGGATGTTGCCGGCGTTTCTTCCAAC
GTCGGCTCATCCTGAAATGCCTCACCTGGTCCCCTCGGGTGTGGCTTCA
GGTGTGAT
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>AGK008LSU

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GCCCACACAAGTGTGGTCGATTCTCTCTCCCCCCCATAACCAATTTTTAA
AAAATTTTTTCGCTCAAAAACCCCCACCCCCCCCCACAGTTTCCCCT
GTGGCTTCCCCCCCCCTCGGGTATAGTTCCCCTTCTTGGGGGCCCAATAT
ACGTGCTCCACCTCAAACCGTCAAAAGGGTGTGGTCGGGGCGTGGGCG
CCCTTCACGACAAAGGTCCCAACCTTTCACTTTCTTTTCGCACAAGGGTT
TTCCACCCTAATACTCGCAGGCATGTTAGACTCCTTGGTCCGTGTTTCAA
GACGGGTCGTTTAAAGCCACTACGCCCTCATCCTAAGCATGTTACGTGGG
CCACCCCGGACATTAGAGGGATGCTGCGGTCCTCAATCCCGGCCGTCAT
ATACCATAGGGGGCTATAACACACCATAAGGTGCCACCTTCCCCCACCC
TTATCTGACGATCGAAATTGATGCTGGCCCCTCCCCTCGGGAAGTGCAC
ACACAAAAGTGAAGCTGAGTCCCAGACACGCGACTGATTTCAATCTTTT
CCCTTTAAACAATTTACGTAAGTGTGACTCTCTTTCCAAAGTGCTTTT
CATCTTTCCCTCACGGTACTTGTTCGCTATCGGTCTTCCGCCATTATTTA
GTTTTAGATGAAATTTACCCCTATTTTGAGCTGCATTCCCAAACAAC
TACTCTTTAGAGAGCACATGACA
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AGK 035- - *Ramaria myceliosa* (Peck) Corner

(Plate I, Figure 2)

GenBank accession: JQ408230

Basidiocarp:

Habitat – on leaf duff in deciduous woods (elm, red oak)

Color- - Light orange cream color [lighter than 5B7 – golden yellow (-)] branches and stipe, apices concolorous or slightly lighter, context cream [3A3 pale yellow (cream color)].

Taste- - slightly bitter, musty

Odor- - fragrant, almost fruity

Form- - basidiocarp small to medium, up to 5 cm tall by 2.75 cm wide by 1.25 cm deep, branches 0.4 cm wide or less, stipe base 0.7 cm wide. Polychotomous branching, shorter stocky branches forming a very dense structure, apices acute and flexible. White basal tomentum on entire stipe to the point of branching (not downy). Fruit bodies form mycelial mats that are less dense than similar looking *Lentaria micheneri*.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: yellow orange [5A7- (deep chrome)]

Spore: (at 1250 μm) range: 4.74 -5.53 x 3.16 (-3.95), average: 5.14 x 3.2, E value: 1.61, L^m : 5.14, W^m : 3.16, E^m : 1.63, oval or slightly reniform with echinulate ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative hyphae with clamps, supporting hyphae with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 035	Wild River State Park, MN	24 July 2010
MCBS153	Camden State Park, top of the Dakota Valley Trail, MN29	Aug 2007
MCBS266	Paul Bunyan State Forest, MN	28 Sep 2007

Distribution: USA- CA, ID, MI, MN, NW, NY, OR, WA; Canada- Manitoba; Europe- Finland, Germany, Italy, Sweden

Discussion: The specimen matches the description of *R. myceliosa*, having appropriate L^m and E^m values (Exeter 2006). The Wild River habitat does contain coniferous trees though none were noted for this collection.

AGK 012- - *Ramaria sp. 1*

(Plate I, Figure 3)

Basidiocarp:

Habitat – on decaying wood, with *Xylaria* and moss, deciduous woods (basswood and box elder)

Color- - light yellow brown [3A4-pastel yellow (Maize yellow) stipe and cream tan [4A5-butter yellow (buff-yellow)] branches and apices, turning bole brown [6F7 chestnut brown (-)] on branches and apices with age; cream [3A2-yellowish white (light buff), 3A3-pale yellow (cream)] context.

Taste- - weakly bitter Odor- - not distinct

Form- - basidiocarps medium, up to 7 cm tall by 4 cm wide, upper branches less than 0.1 cm wide, stipe 0.4 cm wide. Polychotomous branching, thick rubbery branches, glabrous, apices acute. Thin white basal tomentum.

Macrochemical Reactions:

Bruising reaction: no obvious bruising.

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: 4.74-5.53 x 2.37-3.16 (-3.56), average: 5.41 x 2.63, E value: 2.06, L^m : 5.53, W^m : 2.37, E^m : 2.33, subfusiform or oblong elliptical with echinulate ornamentation.

Basidia: Four sterigmata, with clamps

Hyphae: Generative hyphae with clamps, supporting hyphae in lower stipe context

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 012	Pin Oak Prairie Scientific and Natural Area, MN	10 July 2010

Discussion: Very similar to *R. stricta* but having echinulate ornamentation. ITS sequence did not yield a match in GenBank and the LSU portion of the sequence is too short to be useful. Specimen is old and morphologically closest to *R. argentea* but has a significantly different E^m value, L^m , and spore averages (Exeter 2006). AGK 012 does not match any known *Echinoramaria* species in Petersen (1981).

> AGK012 Consensus sequence

```
TTTGAAGGTGACTGCGGAGGACATTATAGAAGCTTGACTGGGGGGGCTGT
GGCCGTCTCGGCCCTCGGCCACACTCTGCCATTCTTCAAATCCCACA
CCCTCTTTTGTGCCATCTGTTTCTCGCCCCCCCCGACCCGTCGTCCCGC
GAGCGCCCCTCTGGGGCCAGTTCACCTTCTTTTCTTCCAATTCTTACTC
CAGCCAAAACCTCCTAAGAAGATTCTACCAATTTAATTTTTGATAAGAAAT
TTTTGGACTTTCTTAACTTACAAAGAATTACGCAATTCCAAAATAAACGA
ATCTTTCAACACATCGTGCCCTCCTTGATCTTCCCACAATCATTGCCCTT
TTCGTCTTGTCAAGGGCAACCGCCCTCACTTCTTTCTGTCCCCATTCCC
TTTTAATCTTCCTTCGCCGACCCGRGKSTTAATCTGGAGAGGCGTCTTCC
CGCGCCGGACGGTGTACAAGTGCCCCTGGGAACGGGGCGTCATAGAGGGT
GAGAATCCCGTCTTCGACACGGACCGCCGGCGCCATGTGATGCGCTCTCG
AAGAGTCGAGTTGTTTGGGAATGCAGCTCAAATCGGGTGGTAAATTCCAT
CTAAAGCTAAATATTGGCGAAAGACCGATAGCGAACAAGTACCGTGAGGG
AAAGATGAAAAGCACTTTGGAAAGAGAGTTAAACAGTACGTGAAATTGTT
GAAAGGGAAACGATTGAGGTCAGTCGCGTCTCCCGGGACTCAGCCTCGCT
TCTGCGAGGCGTACTTCCCGGGGCGACGGGCCAGCATCGATTCGACCGC
CGGAGAAAGGCGGGGGGAACGTGGCACCTTCGGGTGTGTTATAGCCCCC
GTCGTATGCGGCGGTCTGGGATCGAGGACCGCAGCGTGCCCCTTCGCGGG
GGCCGGGGTTCGCCACGTAACGCGCTTAGGATGCTGGCGTAATGGCCTT
AAACGACCCGTCTTGAAACACGGACCAAGGAGTCTAACATGCCTGCGAGT
GTTTGGGTGGAAAACCCGGACGCGTAACGAAAGTGATAGGTTCGGGACCTC
TGTCGCGGAGGGCACCGACGCCCGGACCAGAGCTTCTGTGACGGATCCGA
GGTAGAGCATGTATGTTGGGACCCGAAAGATGGTGAACATGCCTGAGTA
GGGTGAAGCCAGAGGAAACTCTGGTGGAGGCTCGTAGCGATTCTGACGTG
CAAATCGATCGTCGAACTTGGGTATAGGGGCGAAAGACTAATCGAAACCA
TTCTTAGCGCCCTT
```

AGK 033- - *Ramaria sp. 4*

(Plate I, Figure 4)

GenBank accession: JQ408229

Basidiocarp:

Habitat – on soil and duff layer in deciduous woods (red oak, elm)

Color- - Light brown buff [4B8 – yolk yellow (-), 5B8- ‘orange’ (-)] branches and stipe. Apices concolorous or a lighter cream [3A2- yellowish white (light buff)]. Cream [3A3 pale yellow (cream color)] context.

Taste- - bitter Odor- - not distinct

Form- - basidiocarp small to medium, up to 3 cm tall by 2 cm wide, branches less than 0.2 cm wide, stipe 0.2 cm wide. Dichotomous branching, branches round in cross-section, apices forked acute. A small amount of basal tomentum at very base of stipe.

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 µm) range: 4.74-6.32 x 2.37-3.16, average: 5.57 x 2.47, E value: 2.26, L^m: 5.53, W^m: 3.16, E^m: 2.33, fusiform-elliptical with echinulate ornamentation. Spores stick together.

Basidia: Four sterigmata, clamps

Hyphae: Generative hyphae with clamps

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 033	Wild River State Park, MN	24 July 2010
AGK 037	“	“
AGK 038	“	“

Discussion: Specimen is very close to *R. myceliosa* in morphology but the E^m and L^m values are significantly off from the species description (Petersen 1981). The ITS sequence is 98% similar to *R. cystidiophora* with 59% coverage but the specimen does not have verrucose spores. The three specimens (AGK 033, 037, 038) are most closely related to one another.

AGK 063- *Ramaria* sp. 7

(Plate II, Figure 5)

Basidiocarp:

Habitat - - on rotting log and branches in deciduous woods (maple)

Color- - Orange cinnamon brown [5B5- grayish orange (-), 6B5-greyish orange (cinnamon), lightening to 4A5-butter yellow (buff yellow), 3A5- light yellow (Baryta yellow)] branches, apices, and stipe, cream [3A3- pale yellow (cream color)] context.

Taste- -bitter but requires chewing

Odor- - cocoa and something else

Form- -basidiocarp medium, 13.5 cm tall by 6.5 cm wide by 5 cm deep, branches up to 1 cm wide, stipe base up to 0.5 cm. Polychotomous branching, up to ten tiers of branches, occasionally flattened at axil or fused, pointy acute. Multiple fruit bodies on the same log, forming massive clusters but having slim fine branches with very little weight.

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid
Gum Guaiac: positive
Microscopic Structures:

Spore print: orange brown [5A7- (deep chrome)]
Spore: (at 1250 µm) range: 3.95 – 4.74 x 2.37 -3.16, average: 4.38 x 2.73, E value: 1.60,
L^m: 4.74, W^m: 2.37, E^m: 2, subfusiform s with echinulate ornamentation.
Basidia: Four sterigmata, clamped.
Hyphae: Generative hyphae with clamps

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK063	Pin Oak Prairie Scientific and Natural Area, MN	07 Aug 2010

Discussion: Specimen is not closely related to any GenBank *Ramaria* sequence or other collection. The spore range of the collection is significantly smaller than any subgenus *Echinoramaria* species and that of AGK012.

>AGK063ITS

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CTTTTAGTGACTGCGGAGGACATTATAGAAGCTTGACTGGGGGGGCTGTG
GCCGTCGGGCGTCTCGCCTCGACGCGCACGCCCTTCACTTCAAATCCCA
CAAACACTTCTGTGCACCATAGGTCTCGTGCCCCCATGAGGAGCCGTC
CGCGAGAGCGGGGCCGGGGCCGTGTTCTTCCATTACATCCAGTCCTCT
CGCATGTGTAATCGCCCCGGCGAGCTTTGACAATTACAACCTTCAACAAC
GGATCTCTTGGCTTTCGCATCGATGAAGGACGCCGCGAAAGTGCTAAACG
TAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTAAACGCATCTT
GCGCCCCTTGGTATTCCGAGGGGCATGCCTGTTTGAGCGTCGTAAACTAA
AATCCACCCTTGGACTTTGTAATGTGGTCCCGGGGGCGGATTTGGGTGCT
GCGGGTCCC GGTTTTGAGTCCGATCG
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>AGK063LSU1

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GGGCATTTAATGGTTCGATTAGTCTTTTCGCCCTATACCCAAGTTCGACG
ATCGATTTGCACGTCAGAATCGCTACGAGCCTCCACCAGAGTTTCTCTG
GCTTACCCTACTCAGGCATAGTTCACCATCTTTTCGGGTCCCAACATA
TGCTCTACCTCGGATCCGTCACAGAAGCTCTGGTCCGGGGCGTCGGTGCC
TCCGCGACAGAGGTCCCGACCTATCACTTTCGTTACGCGTCCGGGTTTT
CACCCAAACACTCGCAGGCATGTTAGACTCCTTGGTCCGTGTTTCAAGAC
GGGTCGTTTAAGGCCATTACGCCAGCATCCTAAGCGCGTTACGTGGGCGA
ACCCCGGCCCGCGAAGGGGCACGCTGCGGTCCCTCGATCCCAGACCGCC
GCATACGACGGGGGGCTATAACACACCCGAAGGTGCCACGTTCCCCCGC
CTTTCTCCGGCGGTTCGAAATCGATGCTGGCCCGTCGCCCCGGGAAGTACG
CCTCGCAGAAGCGAGGCTGAGTCCCGGGAGACGCGACTGACCTCAATCGT
TTCCCTTTCAACAATTCACGTA CTGTTTAACTCTCTTTCAAAGTGCTT
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TTCATCTTTCCTCACGGTACTTGTTTCGCTATCGGTCTTTCGCCAATATT
TAGCTTTAGATGGAATTTACCACCCGATTTGAGCTGCATTCCCAAACAAC
TCGACTCTTCGAGAGCGCATCACATGGCGCCGGCGGTCCGTGTCGAAGAC
GGGATTCTCACCTCTATGACGCCCCGTTCCAGGGGACTTGTACACGGTC
CGGCGCGGAAGACGCTTCTCCAGATTACAACCTCGGACGACCGGAGGCCGC
CAGATTACAAATTTGAGCTCTTCCCGCTTCACTCGCCGTTACTAGGGGAA
TCCTCGTTAGTTTCTTTTCCCTCCGCTTATTGATATGCTTAAGTTCGGCGG
GTAGTCCCACCT

Subgenus *Laeticolora*

DJM1629- *Ramaria acrisiccens*

(Plate II, Figure 6)

Basidiocarp:

Habitat - - on ground in mixed woods (oak, aspen, tilia, white pine)

Color- - yellowish brown to pale orange branches, apices pale to light yellow, stipe white to yellow white, stipe flesh color yellow white to yellow gray.

Taste- - mild, not distinct, pleasant

Odor- - pleasant, slightly fragrant

Form- - basidiocarp medium, 7.3 cm tall by 5.0 cm wide, branches up to 0.2 cm wide. Dichotomous to polychotomous branching, apices subacute to blunt. Subtomentose on stipe base.

Macrochemical Reactions:

Bruising reaction: none

Ferric Sulphate: n/a

Melzer's: nonamyloid

Gum Guaiac: n/a

Microscopic Structures:

Spore print: yellowish white macroscopically

Spore: (at 1250 μ m) range: (9.3-) 9.8 -11.8 (-12.0) x (3.4-) 3.9 - 4.4 (-4.9), average: 11 x 3.9, subfusiform-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, unclamped

Hyphae: Generative hyphae, unclamped

Collections

Number

Location

Date

DJM1629

Itasca State Park, MN

17 Aug 2009

Distribution: USA- CA, ID, OR, WA

Discussion: *R. acrisiccens* is the best morphological fit for the specimen.

AGK 077- *Ramaria cf. acrisiccescens* Marr and Stuntz

(Plate II, Figure 7)

Basidiocarp:

Habitat - - on soil in deciduous woods (red oak, maple, elm)

Color- - Buff cream [4A4-light yellow (cream-buff), 4A3-cream (pale yellow-orange)]
stipe, branches and apices. Cream [3A3-pale yellow (cream color)] context.

Taste- -not distinct

Odor- -earthy fresh but not distinct

Form- -basidiocarp medium to large, up to 12 cm tall by 9.5 cm wide by 6.5 cm deep,
branches 2 cm to 0.2 cm wide, stipe base 2.5 cm wide. Dichotomous branching, stocky
and tough branches but flexible, branches flattened in axils, apices cupsid (having
flattened portions and uneven tips). White basal tomentum (marshmallow fluff) on stipe
at soil level, hymenium wrinkled giving the impression of striations, slight browning with
age.

Macrochemical Reactions:

Bruising reaction: not rapidly brunnescent

Ferric Sulphate: positive, dark purple blue

Melzer's: nonamyloid

Gum Guaiac: positive, light teal blue

Microscopic Structures:

Spore print: orange yellow [5A6-melon yellow (capucine orange), 5A7- (deep chrome)].

Spore: (at 1250 μm) range: 8.69-11.06 x (3.16-) 3.95, average: 9.95 x 3.91, E value: 2.55,
 L^m : 10.27, W^m : 3.95, E^m : 2.6, oblong-elliptical with verrucose (very small bumps)
ornamentation

Basidia: Four sterigmata, unclamped

Hyphae: Generative hyphae unclamped and skeletal hyphae.

Collections

Number

Location

Date

AGK 077

Itasca State Park, MN

18 Aug 2010

Distribution: USA- CA, ID, OR, WA

Discussion: The morphology of the specimen best matches *R. acrisiccescens* but ITS
sequence does not match or place the specimen close to that species. The spores of the
collection tend to be wider but every other character of the specimen is appropriate for
this species.

> AGK077 Consensus Sequence

CCTGCAGCGACTGCGGAGACATTACAGTATGATTAGGGGGTTAGATGCTG
GCCCCGTGAGGGCATGTGCGCACCCCATCTTCTAATCCCACACACACCTG
TGCACCTATGGAGAGCGCCTCCCATCTTGGAGTCGTCTGGCGTCCTTCTC
TCTCTTCGGAGGGTGGGGGAGGCTGGACTGGGGTGCTCTCTCTTTTACA
TCTCAGCCTGTAAAATGCATGTCTTTTGGAGCCCTACGGGGGTGGAAAAT
TGTAATACAACCTTCAACAACGGATCTCTTGGCTTTTCGCATCGATGAAGA
ACGCCGCGAAAGTGCGAAACGTAATGTGAATTGMMGAATTCTCATGTRAW
TCATTCGAATYYYTGAAGTGCATCTTGCCTCCTTGGWATTCCGAGGAKC
ATGCCTGTWTGAGTGTCCGTGAWMCCYTCTCGACCCTCCTTCTTTGCTGA
AAGGAGGGTTGRWTTYGRACGCTGCRGTCKGRCTYCCCATCGCTCGTCT
CTAAATGCATCAGCTGGTCCCATAGKAGTTGGTYTGACGATGGTGTGATA
ATATACTTTTTGTTGACTGTGGCGCCGTCTTAGGCCGACTCTGAACCK
GGSCCGCTCATAGCSGTCTTCGGACAATGATTTTCATGTCGTCTGACCTCA
AATCAGGTAGGACTACCACKCTGAACCTYMWGCATATCAATAARCGGAGG
AAAARAACTAATCAAGAGATTCCCCTCASYAACGGCSAGTGAAGTCGGT
GAAGARCTCAMAKWTGYWMTCSYSGCGSCTGTGCGSCCGKCCGAGTKGKAG
TSTGGASAGAGCGTWTCTKCGWCGSAYCGTSTRMAAKWMMCTYGGAAGG
SAGCGSGTTCGMCAGAGGAGAAWRASAATCCTCKTCTYYGACASKSMSYG
SCKGTKMYWTGKGAKRCGCTCTCGAAGAGTMSAGTTSTTYKKGKWRYGCAK
YKCRMAACGRGKGGKARAYKCMCTCTMWMKMTRAWTAGGWYGRARRAAR
AYCGATAKCGAWCAMSKRCCGTGAGGGRAARRKSWMAAGYASTWTGGARA
GMGAKKYMMACMGYACRTGAAATTGTWKARAGGTGWAACKTTYSAASWCA
STCGCGTWCWCGGSACTCAGCYTKGYCTTKCCGCWTGGWSTACTTCSWRG
GAYGMMGKKMCAKWTYSAWYWKGASMGKCGAGGAGMARGGCTCTCTTR
GGWWMSYSGCACYYTCGRGTGTGTTATAGCCCTTGGTCGCATGCGACGGT
GGGATCGAGGACCGCAGCACGCCGTTTATCGGCCGGGGTTCGCCACGTG
TACCGTGCTTAGGATGCTGGCGTAATGGCTTTAAGCGACCCGTCTTGAAA
CACGGACCAAGGAGTCTAACATGCCTGCGAGTGTTTGGGTGTAAAACCCA
GACGCGGAATGAAAGTGAACGGTTGGGACCTCTGTCGTGGAGGGCACCGA
CGCCCGGACCAGACCTTTTGTGACGGTCCGAGGTAGAGCATGTATGTTG
GGACCCGAAAGATGGTGAACATGCCTGAGTAGGGTGAAGCCAGAGGAAA
CTCTGGTGGAGGCTCGTAGCGATTCTGACGTGCAAATCGATCGTCGAACT
TGGGTATAGGGGCGAAAGACTAATCGAACCATCATTGGTCA

AGK 025- - *Ramaria aurea* (Schaeff.: Fr.) Quél.

(Plate II, Figure 8)

GenBank accession: JQ408226

Basidiocarp:

Habitat – on soil in deciduous woods [collected by R.Healy]

Color- - Slight apricot tinge [4A7-buttercup yellow (light cadmium), 5A7- (deep chrome)] branches and apices that darken with age [4B8-yolk yellow (-)], a cream buff [3A2- yellowish white (light buff)] stipe that yellows upwards, cream [3A3 pale yellow (cream color)] context.

Taste- - not bitter, almost doughy Odor- - not distinct

]

Form- - basidiocarp medium, up to 7.5 cm tall by 7 cm wide by 3.75 cm deep, branches 1.75 cm to 0.1 cm near tip, stipe up to 2 cm wide, stipe base 1 cm wide. The base of the stipe is thin and widens in area of branching. Polychotomous branching with branches almost at right angles to stipe, apices acute or rounded. The stipe base has a white fluffy tomentum.

Macrochemical Reactions:

Bruising reaction: slightly brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive, context positive

Microscopic Structures:

Spore print: orange yellow [4A6 maize yellow (light orange yellow)]

Spore: (at 1250 µm) range: (5.53-) 7.9-10.27 x 3.95-5.53, average: 8.87 x 4.31, E value: 2.06, L^m: 8.69, W^m: 3.95, E^m: 2.2, subfusiform (often more narrow at the opposite end of the apiculus) with verrucose (large amorphous ridges) ornamentation.

Basidia: Four sterigmata, very thin, appear to lack clamps

Hyphae: Generative hyphae lacking clamps

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 025	Nerstrand-Big Woods State Park, Nerstrand, MN	12 July 2010

Distribution: USA- CA, ID, MN, NC, NY, TN; Europe- Austria, England, France, Germany, Italy, Scandinavia, Sweden, Switzerland; Japan; Asia Minor.

Discussion: The specimen ITS sequence yields a GenBank match of 97% to *R. aurantiiscescens* among others. Morphological data matches *R. aurea* (Petersen 1974). The description of the species in Corner (1950) claims that the hyphae are clamped in this species but all other sources list *R. aurea* as clampless.

AGK 072- *Ramaria cf. celerivirescens* Marr and Stuntz

(Plate III, Figure 9)

GenBank accession: JQ408243

Basidiocarp:

Habitat - - on soil in deciduous woods (red oak, elm)

Color- -Light cream brown [5A3-pale orange (-), 5A2-orange white (pale cinnamon-pink)] branches, lighter cream [3A5-light yellow (Baryta yellow)] upper branches and apices, stipe concolorous with light brown [6E8-hazel, rust (cinnamon brown)] striations, cream [3A3-pale yellow (cream color)] context.

Taste- -bitter

Odor- - distinct, almost perfume-like

Form- -basidiocarp medium, up to 10.5 cm tall by 6.75 cm wide by 3.5 cm deep, branches 1 cm wide or less, base 1.5 cm wide or less. Dichotomous branching, lengthy branches that are floppy, apices rounded. White basal tomentum on base of stipe at soil level.

Macrochemical Reactions:

Bruising reaction: brunnescent but not immediate

Ferric Sulphate: light positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: (7.9-) 8.69-10.27 (-11.85) x 3.95-4.74 (-5.53), average: 9.40 x 4.23, E value: 2.22, L^m : 9.48, W^m : 3.95, E^m : 2.4, subfusiform or oblong-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, unclamped.

Hyphae: Generative unclamped hyphae, possible supporting hyphae. Strange thick walled hyphae with waxy appearance and knobby joints, distinctly different from generative hyphae, knobs not always on cross walls, in upper branches.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 072	Nerstrand-Big Woods State Park, Nerstrand, MN	13 Aug 2010

Distribution: USA- CA, ID, OR, WA

Discussion: The specimen matches *R. celerivirescens*, having appropriate spore size and coloration. The habitat for the species is coniferous while the specimen was collected in deciduous woods only. The diagnostic characteristic of a brown band of contextual hyphae was not noted in the specimen and the specimen would need to be recollected and examined when fresh to determine for certain if the species description matches.

DJM1628- *Ramaria cyaneigranosa*

(Plate III, Figure 10)

Basidiocarp:

Habitat - - on ground in mixed woods (oak, aspen, tilia, white pine)

Color- - pale yellowish pink branches with brilliant orange yellow apices. Flesh of stipe white below, pale orange yellow above. Flesh of fertile branches pale orange yellow below, brilliant orange yellow above.

Taste- - mild, pleasant but not distinctive Odor- - pleasant but slight

Form- -basidiocarp medium, 7.3 cm tall by 5.0 cm wide, branches up to 0.5 cm wide, stipe 2.5 tall cm by 3.0 cm wide. Polychotomous branching, rounded apices. Subtomentose stipe.

Macrochemical Reactions:

Bruising reaction: n/a

Ferric Sulphate: n/a

Melzer's: nonamyloid

Gum Guaiac: n/a

Microscopic Structures:

Spore print: n/a

Spore: (at 1600x, μm) range: (7.1-) 11.8 – 12.4 (-13) x (3.1-) 3.9 – 4.3, average: 10.8 x 3.9, E value: 2.64, L^m : 11.5, W^m : 4, E^m : 2.9, oblong-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, unclamped. Cyanophilous granules present (Marr and Stuntz 1973).

Hyphae: Generative hyphae, unclamped.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
DJM1628	Itasca State Park, MN	17 Aug 2009

Distribution: USA- CA, ID, OR, WA

Discussion: Morphology is closest to *R. cyaneigranosa* var. *cyaneigranosa* but the specimen is a lighter pink coloration. Specimen does have cyanophilous granules in the basidia, a diagnostic character for *R. cyaneigranosa*.

AGK 028- - *Ramaria flavigelatinosa* Marr & Stuntz

(Plate III, Figure 11)

Basidiocarp:

Habitat – on soil in deciduous woods (maples, oaks)

Color- - Light brown buff [4A5 butter yellow (buff yellow)] branches and apices, cream white [3A3 pale yellow (cream color)] stipe, cream white [3A3 pale yellow (cream color)] context.

Taste- - bitter Odor- - not distinct

Form- - basidiocarp medium, 7.75 cm tall by 4 cm wide by 2 cm deep, branches 0.6 to 0.1 cm wide, stipe base 1 cm wide. Polychotomous branching with stocky but easily breakable branches, apices tri-pointed. Slight white basal tomentum.

Macrochemical Reactions:

reaction: none apparent

Ferric Sulphate: positive, slow

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: (7.9-) 8.69-9.48(-10.27) x (3.16-) 3.56-3.95 (-4.35), average: 8.97 x 3.89, E value: 2.31, L^m : 8.69, W^m : 3.95, E^m : 2.2, elliptical or oval with verrucose (small warts) ornamentation.

Basidia: Four sterigmata, no clamps, tissue separates easily.

Hyphae: Generative hyphae lacking clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 028	Afton State Park, MN	17 July 2010
AGK 083	Afton State Park, MN	29 Sept 2010

Distribution: USA: CA, ID, OR, WA: Canada- Nova Scotia

Discussion: *R. flavigelatinosa* is a morphologically match to AGK 028 with exception that the species has a coniferous habitat (Marr and Stuntz 1973, Exeter 2006). Genetically the specimen is most closely related to AGK 083 and is likely the same species but there is no significant match to any GenBank accession.

> AGK028 Consensus sequence

TCTGTAGTACTGCGGAGACATTACAGTGTTATCACAACATCGGCGCGGGA
GGGGGGTTTAAGATGCTGGCCCAAAGAGGGCATGTCGTGACTCGCCCC
CTTCCGTTTCCGTTGCTTGCGTATATATCTCCACCCCCGAAAACCTTAGG
GGGGGGGTGCCCCCCCCCTTTTTTAACCCCAACCCCTGTTGAAGCGCG
TGTCTTGAACCCCCACGGGGGTGAATAAAAAATTTTAATACAACCTTCA
ACAACGGATCTCTTGGCTTTCACATCTAAAAAAGACCCCGCAAAGTGCA
AAACGTAATGTGAATTGCAAAATTCAGTGAATCATCAAATCTTTGAACGC
ATCTTGCCTCCTTGGTATTCCGAAGAACATGCCTGTWTSWGYKTCGWGW
RYMCWTCCGMKCSACSYCWSTMMKTGGTAGASTCTS KSKWSGATCKTGAR
ACGCTGYGATRGMCTCGKSGYTCGTGTYKWMATRSATGCATCWGCCG
CCCTCYCTTCGGGTSRGACCTGATCSACGGTGTGWAWATMACAAATCARA
CSCYGT TTTGSCCMRACTTKTGCGTGGKGTCCCKTCTAWMCCCCGTTCCC
CTYGT TTTGGGACCSATTC SACCATTTKACCTCAAATCAK GKAGGAMTAC
CCSCTGAACTTWAGCATATYAATAAGCGGARGAAAARAACTAACGAGGA
TTCCCCTAGTAACSGCGAGTGAAGCGGGAAGARCTCAAATTTGTWATCTG
GCGGCCATTGGCCGTCCGARTTGTARTCTGGARAAGACKYCTTCCGTGCC
GGACCGTGTACAAGTCCCTTTGGAACAGGGCGTCACAGAGGGTGARAATC
CCCSTCTYTGACCACGRWYCSCCGGKGCCTTGTGATGCGCTCTCSAAGA
GTCKAGTTGTTTGGGAATGCAGCTCWAATCGGGTGGTAAATTYCATCTAA
AGCTAAATATAGGCGAAARACCSWTAGCGAACA ASTACYSTGAGGGAAAR
ATRAAAAGCACTTTGGAMAGAGAGTTWAACARTACKTGAAATTGTTGAAA
GRGAAACGCTTGAAGTYWKTCGCGTCTCCCGGGATT CAGCCTCGGCCTCG
GCCGGGGCKWAYTTCCYGGGGCGAMSGGSCARCATYSATTWCGACYSTCG
GAGAAAKGCTCTCKGGAACRTGGCACCTTYKRGTGTGTTATAGCCYGGKS
TACRCRTGCGACGTSTTRRKWWCGARSACSSMASTGCRCCGTTAATTGGT
CGGGGTTTCGCCACGTAACGCGCTTAGGATGCTGGCGTAATGGCTTTAAG
CGACCCGTCTTGAAACACGGACCAAGGAGTCTAACATGCCTGCGAGTGTT
TGGGTGGAAAACCCGGACGCGAAATGAAAGTGAAAGGTTGGGACCCCCGT
CGCGGGGGGCACCGACGCCCGGGCCAGACCTTTTGTGACGGTTCGAGGT
AGAGCATGCATGCTGGGACCCGAAAGATGGTGA ACTATGCCTGAGTAGGG
TGAAGCCAGAGGAAACTCTGGTGGAGGCTCGTAGCGATTCTGACGTGCAA
ATCGATCGTCGAACTTGGGTATAGGGGCGAAAGACTAATCGAACCATCTG
TGGCTT

AGK 075- *Ramaria flavigelatinosa* cf. var. *carnisalmonea*

(Plate III, Figure 12)

Basidiocarp:

Habitat - - on soil in deciduous woods (red oak, maple, elm).

Color- - Younger fruit body has orange cream yellow [5A4-light orange (warm buff), 5A5-light orange (orange buff), 5A6-melon yellow (capucine orange)] branches and apices, older fruit body a light cream brown, cream [3A3-pale yellow (cream color)] context.

Taste- - n/a

Odor- -older: earthy, almost manure- younger: earthy with almost grape scented, hay, silage

Form- -basidiocarp medium to large, up to 10.25 cm by 9.25 cm wide by 5 cm deep, branches 1 cm or less, stipe base 2 cm wide. Polychotomous branching with rounded branches, apices rounded and thick. White basal tomentum (marshmallow fluff) to the point of branching with striations extending past the point of branching. Fruit body slightly brittle.

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range:7.9-9.48 (-10.27) x 3.95-4.74, average: 8.77 x4.44, E value: 1.98, L^m : 8.69, W^m : 4.74, E^m : 1.83,subfusiform with verrucose (dense bumps and ridges) ornamentation.

Basidia: Four sterigmata, unclamped

Hyphae: Generative hyphae, unclamped

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 075	U of M Cedar Creek ESR, MN	15 Aug 2010

Distribution: USA- CA, ID, OR, WA

Discussion: The specimen closely matches the description of *R. flavigelatinosa*. Variety *carnisalmonea* has the appropriate form, orange pinkish coloration to the branches, and correctly sized spores. However, the specimen was collected in deciduous woods and the branch context coloration was not observed for the collection.

> AGK075 Consensus sequence

```
TCGAAGCGACTGCGGAGGACATTACAGTGTTATCACAACATCGGGCGCGGG
AGGGGGGTTTAAGATGCTGGCCCAAAGAGGGGCATGTCGTGACTCGCCCT
CCTTCCGTTTCCGTTGCTTGCATATATATCCACACCCGTGAACCTTAA
TGGGAGGGTTCGCCCCCTCCCCTTTTTTTAAACCAAGCCCGGTGGAAC
GCTGGTCTGGAACCCCCCGGGGGAATTAATAAATTTTAATACACTTT
TCACCACCGATTTTCTGGGTTTTCCCTTCATTAAAGGACCCCCCAAATG
GCAAAGGAAAGGGAWMYKGWARAATTSAYRGATTCACSTSSAATCMYTY
```

RAMYCYTKMWRGSCMCTCTGCCTSKGCWTWCSARGARSCWKGCYKGTTR
AKKKTCTRGMAYCCYTCCTCSACCCSACMCYCYCGKARARTCCKGGWTGG
AATTGGAACKTCKGCGGGKCCTCTCKCGGYYSSTTCTTAAATGCRRYCMR
GGCTGGCCCCYYCACTCCGGGYCGAACCRA YCRACGGTGGKRATAWWAMC
AAATCRAASSCCKTTTGGGCCCGACTTTTGCCKTGGGGTGCCTCYWAMCC
SGGTTCCCCTYGKTTTGGGACCGATTCSACCATTTGACCTCAAATCAGGT
AGGACTACCCGCTGAACTTAAGSATATCAATWAGCGGAGGAAAAGAACT
AACGAGGATTCCCCTAGTAACGGCGAGTGAAGCGGGAMGAGCTCAAATTT
GTAATCTGGCGGCCATTGGCCGTCGAGTTGTAGTCTGGAGAAGCGTCTT
CCGTGCKGAMCGTGTACAAGTCCCTTGGAACAGGKCGTCACAGAGGGTG
AGAWTCCSSTSWYYGAYRCKGATCGYSGRTGCCTYRWGATGCRMSTSTCAA
AGAKTSSAGTYRYYGGKAATCAKYAGCTMWRRYMGCGGWGSKAWRTWCY
AGTMTRRASCYMWYRTAGGSKAMRGTACYGACTRKCAGAWSWRRTMYCG
TKMKGRWMASWYKRAMWGCGRWYTSGRMASRSARTYRAWYASTGAMGT
SRAMTKGTTGAAAGGGAAACGCTTGAAGTCAGTCGCGTCTCCCGGGATTCA
GCCTCGGCCCTCGGCCGGGGCGTACTTCCCGGGGCGACGGGCCAGCATCGA
TTTCAACCGTTCGGAGAAAGGCTCCGGGAACGTGGCACCTTTGGGTGTGTT
ATAGCCCGGGGTCGCATGCGACGGTTGGGATCGAGGACCGCAGTGCGCCG
TTAATTGGTTCGGGGTTCGCCACGTAACGTGCTTAGGATGCTGGCGTAAT
GGCTTTAAGCGACCCGTCTTGAAACACGGACCAAGGAGTCTAACATGCCT
GCGAGTGTGGGTGGAAAACCCGGACGCGAAATGAAAGTGAAAGGTTGG
GACCCCTGTCGCGGGGGGCACCGACGCCCGGGCCAGACCTTTTGTGACGG
TTCCGAGGTAGAGCATGCATGCTGGGACCCGAAAGATGGTGA ACTATGCC
TGAGTAGGGTGAAGCCAGAGGAAACTCTGGTGGAGGCTCGTAGCGATTCT
GACGTGCAAATCGATCGTCAACTTGGGTATAGGGGCGAAAGACTAATCG
AACCATCTTTGCCTC

AGK 059- - *Ramaria flavobrunnescens* var. *aromatica* Marr and Stuntz
(Plate IV, Figure 13)

GenBank accession: JQ408240

Basidiocarp:

Habitat – on soil in deciduous woods (red oak, maple, aspen)

Color- - Light brown cream [4A3-cream (pale yellow-orange, capucine buff), 4A2 – yellowish white (pale ochereous-buff)] branches and apices, slightly lighter stipe, cream [3A3-pale yellow (cream)] context.

Taste- -not distinct

Odor- - slightly fresh, floral

Form- -basidiocarp medium, 8 cm tall by 6 cm wide by 3 cm deep, branches 0.5 cm, stipe widening from 0.8 cm base up to 1.5 cm. Dichotomous branching, rounded branches, apices rounded. Slight basal tomentum at very base of stipe.

Macrochemical Reactions:

Bruising reaction: none apparent
Ferric Sulphate: positive
Melzer's: nonamyloid
Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a
Spore: (at 1250 μ m) range: (7.11-) 8.69-11.06 (-11.85) x 3.95, average: 10.11 x 3.95, E value: 2.56, Lm: 10.27, Wm: 3.95, Em: 2.6, subfusiform with verrucose (small warts) ornamentation.
Basidia: Four sterigmata, often three, clamped.
Hyphae: Generative hyphae with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 059	Lake Alexander Woods SNA, MN	28 July 2010

Distribution: USA: CA, ID, OR, WA

Discussion: Specimen matches *R. flavobrunnescens* var. *aromatica*, with the exception of not being collected in a coniferous habitat. The ITS sequence has a 98% match with *R. flavobrunnescens* var. *aromatica*.

AGK 058- - *Ramaria foetida* Petersen

(Plate IV, Figure 14)

GenBank accession: JQ408239

Basidiocarp:

Habitat – on soil in grass in mixed woods (box elder, red pine, maple, red oak).

Color- - Light yellow brown [4A5 – butter cream (apricot yellow, light cadmium), 4A4-light yellow (pale orange-yellow)] branches, apices, and stipe. Cream [3A3-pale yellow (cream)] context.

Taste- - not distinct

Odor- -astoundingly fetid rotting manure (old fruit body), otherwise not distinct

Form- -basidiocarp medium, 10.5 cm tall by 2.5 cm wide by 2 cm deep, branches 0.7 cm wide and smaller, stipe base 0.7 cm. Dichtotomous branching, branches round, lanky, floppy and rubbery texture, apices rounded. White basal tomentum very thin at base, brown striations.

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive
Melzer's: nonamyloid
Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: 7.9-8.69 (9.78-10.3) x 3.95 -4.74, average: 8.65 x 4.31, E value: 2.01, L^m : 8.69, W^m : 3.95, E^m : 2.2, subfusiform-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, often three, lacking clamps.

Hyphae: Generative hyphae lacking clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 058	Lake Alexander Woods SNA, MN	28 July 2010

Distribution: USA- CA (Mendocina County)

Discussion: The specimen description best matches *R. foetida*, having appropriate spore values, habitat, and the diagnostic unpleasant smell (Exeter 2006). The ITS sequence of the specimen does not closely match anything in GenBank.

DJM1507- *Ramaria cf. longispora*

(Plate IV, Figure 15)

Basidiocarp:

Habitat - - on hummock in moss under Tilia and ash with red oak and maple nearby

Color- - pale orange, whitish base or stipe, apex with light orange yellow, then moderate orange yellow with white base

Taste- - mild Odor- - mild, pleasant

Form- - basidiocarp small to medium, 5 cm tall by 3.5 cm wide, stipe 1.5 cm by 1.5 cm, branches up to 0.7 cm wide. Dichotomous to polychotomous branching, apices acute. White subtomentose on stipe base.

Macrochemical Reactions:

Bruising reaction: none

Ferric Sulphate: n/a

Melzer's: nonamyloid

Gum Guaiac: n/a

Microscopic Structures:

Spore print: yellowish

Spore: (at 1250 μm) range: 11.1 -13.4 x (3.2-) 3.6 - 4 (-4.7), average: 12.64 x 4, L^m : 12.64, W^m : 4, E: 3.1, E^m : 3.2, oblong-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, unclamped.

Hyphae: Generative hyphae, unclamped.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
DJM1507	Mille Lacs Kathio State Park, MN	17 Sep 2008

Distribution: USA- CA, ID, OR, WA

Discussion: *R. longispora* is the closest morphological match to the specimen, though the spore average of the specimen is smaller than in the species description.

AGK 057- - *Ramaria pusilla* Corner

(Plate IV, Figure 16)

Basidiocarp:

Habitat – on soil in deciduous woods (maple, white oak, aspen)

Color- - Light yellow [3A2 yellowish white (light buff)] branches and apices, yellow cinnamon [4B8 – yolk yellow (-), 5B8 – ‘orange’ (-)] stipe, cream [3A3-pale yellow (cream)] context.

Taste- - very bitter

Odor- -not distinct

Form- - basidiocarp small, 3.5 cm tall x 2 cm wide, branches 0.2 cm and less, stipe 0.4 cm. Dichotomous branching, very short branches making fruit body a brush shape, apices biforked acute. White basal tomentum, felt-like and sparse, halfway up the stipe.

Macrochemical Reactions:

Bruising reaction: very slightly brunnescent.

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: (3.95-) 4.74-5.53 x 3.16, average: 5.08 x 3.16, E value: 1.61, L^m : 5.53, W^m : 3.16, E^m : 1.75, subfusiform-elliptical with tuberculate-nodulose (rounded, individual bumps) ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative hyphae with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 057	Lake Alexander Woods SNA, MN	28 July 2010

Distribution: USA: Great Lakes region and Eastern NA, NY, OR; Canada- Ottawa
Discussion: The specimen is not genetically similar to any other collection or *Ramaria* accession on GenBank but does morphologically match *R. pusilla*. AGK 057 lacks the vinescent bruising reaction noted for the species by Corner (1950) and Smith et al (1981) but the description of the type specimen, studied by Marr and Stuntz (1973), does not mention a vinescent bruising reaction.

> AGK057 Consensus sequence

```
GGGGACTGGATGGTTCGAATAGTCTTTCGCCCCTATACCCAAGTTCGACG
ATCGATTTGCACGTCAGAATCGCTACGAGCCTCCACCAGAGTTTCCTCTG
GCTTCACCCTACTCAGGCATAGTTCACCATCTTTCGGGTCCCAACATACA
TGCTCTACCTCGGAACCGTCACAAAAGGTCTGGTCCGGGCGTCCGGTGCC
TTCACGACAAAGGTCCCAACCTTTCACTTTCATTTTCGCACAAGGGTTTTT
CACCCTAATACTCGCAGGCATGTTAGACTCCTTGGTCCGTGTTTCAAGAC
GGGTCGTTTAAAGCCATTACGCCAGCATCCTANAGCATGTTACGTGGGCG
AACCCCGGCCATTAGAGGCATGCTGCGGTCTCAATCCCGGCCGTCATAT
ACGATAGGGGGCTATAACACACCCTAAGGTGCCACATTCCCCCACCCTT
ATCTGACGATCGAAATTGATGCTGGCCCGTCCACTCGGGAAGTGCCTAN
CACAAAAGTGNAAGCTGAGTCCCGAGNAGANCGCGACTGACTTCAATCGT
TTCCCTTTCAACAATTTACGTAAGTCTGTTTACTCTCTTTCCAAAGTGCTT
TTCATCTTTCCCTCACGGTACTTGTTCGCTATCGGTCTTTCGCCAATATT
TAGCTTTAGATGGAATTTACCACCCATTTTGAGCTGCATTCCCAAACAAC
TCGACTCTTCGAGAGCACATCACATGGCACTGGCAGTCCGTGTCTAAGAC
GGGATTCTCACCTCTATGACGCCCTGTTCCAAGGGACTTATACACGGTC
CAGCACGGAAAATGCTTCTCCAGACTACAACCTCGGACAGCCATAGACCGC
CAGATTACAAATTTGAGCTCTTCCCGCTTCACTCGCCGTTACTAGGGGAA
TCCTTGTTAGTTTCTTTTCCCTCCGCTTATTGATATGCTTAAGTTCAGCGG
GTAGTCCTACCTGATTTGAGGTCAGAATTGGGTCAAATTACATGATTGTC
CGAGGACCATTAGAAGCGGACCAAACGAGATGNAAGGCTCATATCAACAA
GGCGTCAAAGCTACACTTANTCACACCTCGAGCCAACACCCGACGGGACC
AGCTGATGCATTTCAAGATGAGNCCGACGTTAGAAGAAACGNCCGGCAAC
ATCCAAATCCGACTCCCATTGACATGAAAACACANTCAAGGGGTTCGANG
NCATNGTTCACGACACTCAAACAGGCATGCTCCTCGGAATACCAAGGAGC
GCAAGATGCGTTCAAAGATTCGATGATTCACTGAATTCTGCAATTCACAT
TACGTTTCGCACTTTCGCGGCGTCTTTCATCGATGCGAAAACCAAGAGAT
CCGTTGTTGAAAGTTGTATTACAATTTCCGATTACCCAAATACATGCATA
TAGACAGGCATAAGTGATGGAATCAATGGTGCGAGCCTCAGTCCCGCCCC
CCCTTCAGCCCCGAAGGACCAAAGAGGTTACACGGGACGGCTCCTCATGG
GAGGCTCACCCACAGGTGCACAAGTGTGTATGGGGATTAGAAGTAGAGAC
GGCGTGCATTTGCTCCCCGAGGGGGCCAGCTACAACCGTCCCATTACAT
TCTGTAATGTCCTCCGCAGTTAACCTACA
```

AGK 069 - *Ramaria cf. rasilisporoides* Exeter

(Plate V, Figure 17)

GenBank accession: JQ408242

Basidiocarp:

Habitat - -on soil in deciduous (maple, red and white oak)

Color- - Cream yellow [4A4 light yellow (cream buff), 4A3- cream (capucine buff), 3A2 yellow white (light buff)] stipe, branches, apices. Cream [3A3-pale yellow (cream color)] context.

Taste- -not distinct, not bitter

Odor- -fresh

Form- -basidiocarp medium to large, 14 cm tall by 14.5 cm wide by 8.5 cm deep, branches 2 cm wide or less, stipe base 3.5 cm wide, upper stipe 3 cm or smaller. Polychotomous branching, mostly rounded branches, apices rounded. Either multiple stipes fused at base or large bulbous branches. Some white basal tomentum on stipe base.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: faint positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: (7.11-)7.9-8.69 (-9.48) x (3.16-) 3.95 (-4.74), average: 8.30 x 3.94, E value: 2.10, L^m : 8.69, W^m : 3.95, E^m : 2.2, subfusiform or oblong-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative hyphae with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 069	Nerstrand-Big Woods State Park, Nerstrand, MN	13 Aug 2010

Distribution: USA-OR

Discussion: The specimen matches the description of *R. rasilisporoides* including the diagnostic characteristic of having a deeply rooting base. AGK 069 was found in deciduous woods, not in coniferous. The species is only reported in Oregon and there are very few collections but AGK 069 is convincingly similar to the description.

AGK 056I- - *Ramaria cf. rubiginosa* Marr & Stuntz

(Plate V, Figure 18)

Basidiocarp:

Habitat – on soil in deciduous woods [collected by R. Healy]

Color- - Cream yellow [4A7- buttercup yellow (apricot yellow, light cadmium), 4A6 – maize yellow (light orange-yellow)] stipe, branches, and apices, cream [3A3-pale yellow (cream)] context.

Taste- - not distinct

Odor- - chemical, formaldehyde

Form- - basidiocarp medium, 9.5 cm tall by 6.5 cm wide, branches 1.2 cm wide and less, stipe base 1.4 cm wide. Dichotomous branching, branches round, apices rounded acute. White basal tomentum on stipe to the point of branching. Spongy context but hymenium is easily punctured and brittle.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: yellow brown [5A6-melon yellow (capucine orange), 5A7 – (deep chrome)].

Spore: (at 1250 μm) range: (7.11-) 7.9-9.48 x 3.95-4.74, average: 8.57 x 4.47, E value: 1.92, L^m : 8.69, W^m : 4.74, E^m : 1.83, subfusiform with verrucose (minutely bumpy) ornamentation.

Basidia: 4 sterigmata, lacking clamps.

Hyphae: Generative hyphae lacking clamps, septa are very distinct.

Collections

Number

Location

Date

AGK 056I

Lake Alexander Woods SNA, MN

26 July 2010

Distribution: USA: CA, ID, OR, WA

Discussion: Though the specimen lacks vivescent bruising and was collected in a deciduous habitat, the morphology best matches *R. rubiginosa* (Exeter 2006). The bruising reaction of the fruitbody is a diagnostic character of the species.

> AGK056i Consensus sequence

```
CCTGTTAGCGACTGCGGAGGACATTACAGTGTTATCACAACATCGGCGCG  
GGAGGGGGGTTTAAGATGCTGGCCCAAAGAGGGCATGTCGTGACTCGCC  
CTCCTTCTGTTTCCGTTGCTTGCGTATATATATCCACACCCGTGAACCTT  
AATGGGAGGGTTCGCCCCCTCCCCCTTTTTTAAACCAAACCTGTTGAAA
```

CTCATGTCTTGAATCCCCACCGGGGTGAGTAAAAGAGGTTTAATACAAC
TTTCAACAACACTGATCTCTTGGCTTTCCTATCCTTGAACGACGCCGAGAAA
GTGCGAAACATAATGTGAATTGCAGAATTCTGTGAATCTTCGAATCTTTG
AACGCCTCTTGCCCTCCTTGGCATTCCTAGSAWYMYGYCTSTCTKGASTK
YGKWGAMGTCKTCCSTAASGWCSSSACCTCCTCGGWCMCRMTCTSKGTWGR
AKTTGGRTGWWTGMGGRKTC SYMKS KCTCGCGTSTYTAAGWGTCATSMW
STRGCCCCYYCYWTCYSMTCGRACCGATCGRCGKKWKGATAATAACAAAT
CARAMGCCGTTTTGGCCCGACTTTKGC GTGGGGTCGCTTCTAGCCCCCGC
KCCCCCYCKTTTKSSACCSATTYKRSCATTTGACCYCAMATCAGGTAKG
AYWACCCGCTGAACTTAMSCRTATCAATAAGCGKAGGAAAARAAACWAAM
RARRATTCYCTRKWAACSSCSAGTGWARCGGGAAGAGMTCARATTWGWA
MTCTGGYGKCCATTGGGCSGYCCSAGTTGTAGTCTGGAGAARMGTCTTCM
GTGCCGKACCSYGTACAARTCCCTTKRAAMASGSCGTCACAARAGGGTGA
CRAAWCCCGKCTTTRACACGGWYYSCCGSKGCCTTSTGMTGYGCTCTCGA
AGAGTCGAGTTGTTTGGGAATGCAGCTCAAATCGGGTGGTAAATTCCATC
TAAAGCTAAATATAGGCGAAAGACCGATAGCGAACAAGTACCGTGAGGGA
AAGATGAAAAGCACTTTGGAAAGAGAGTTAAACAGTACGTGAAATTGTTG
AAAGGGAAACGCTTGAAGTCAGTCGCGTCTCCCGGGATTACAGCTCGGCC
TCGGCCGGGGCGTACTTCCCGGGGCGACGGGCCAGCATCGATTTGACCG
TCGGAGAAAGGCTCCGGGAACGTGGCACCTTTGGGTGTGTTATAGCCCGG
GGTCGCATGCGACGGTTGGGATCGAGGACCGCAGTGCGCCGTTAATTGGT
CGGGGTTTCGCCACGTAACGCGCTTAGGATGCTGGCGTAATGGCTTTAAG
CGACCCGTCTTGAAACACGGACCAAGGAGTCTAACATGCCTGCGAGTGTT
TGGGTGGAAAACCCGGACGCGAAATGAAAGTGAAAGGTTGGGACCCCCGT
CGCGGGGGGCACCGACGCCCGGGCCAGACCTTTTGTGACGGTCCGAGGT
AGAGCATGCATGCTGGGACCCGAAAGATGGTGA ACTATGCCTGAGTAGGG
TGAAGCCAGAGGAAACTCTGGTGGAGGCTCGTAGCGATTCTGACGTGCAA
ATCGATCGTCAACTTGGGTATAGGGGCGAAAGACTAATCGAACCATCCA
TGGTCTA

AGK 078- *Ramaria rubricarnata* var. *pallida* Petersen and Scates

(Plate V, Figure 19)

Basidiocarp:

Habitat - - on soil in deciduous woods (red oak, elm, birch).

Color- - Light cream buff [4A4-light yellow (cream-buff), 4A3-cream (pale yellow-orange)] stipe, branches, and apices. Translucent cream [3A3-pale yellow (cream color)] context.

Taste- -bitter

Odor- -fresh but slightly fetid

Form- -basidiocarp medium to large, up to 13 cm tall by 16 cm wide by 7.5 cm deep, branches 1 cm or less, base up to 3.5 cm wide. Multiple stipe bases fused to make enormous clusters. Dichotomous branching, slender and thin branches, apices acute.

White basal tomentum (marshmallow fluff) going up stipe in a striate-like pattern, stipe base thick and spongy.

Macrochemical Reactions:

Bruising reaction: slight brunnescent
Ferric Sulphate: light positive
Melzer's: amyloid context
Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a
Spore: (at 1250 µm) range: 10.27-11.85 (-12.64) x 3.95-5.53, average: 11.10 x 4.54, E value: 2.44, L^m: 11.06, W^m: 4.74, E^m: 2.33, subfusiform with verrucose (possibly striate) ornamentation.
Basidia: Four sterigmata, clamped.
Hyphae: Generative hyphae clamped.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 078	Itasca State Park, MN	18 Aug 2010
AGK 079	“	“

Distribution: USA- CA, ID, OR, WA

Discussion: The morphology of the specimen and the coloration of the fruit body match *R. rubricarnata* var. *pallida*. The specimen does have slightly smaller spores and is found in a deciduous habitat.

> AGK078 Consensus sequence

```
TCTGTTGGGGACTGCGGAGGACATTAACGTATGATTAGGGGGTTAGATGC
TGGCCCGCAAGGGCACGTGCGCGCCCCCTCTTCAAATCCCCATACACCT
GTGCGCCTTCGGCGAGCGCCTCCCCTTCTGAGCCCTCCCGCGTCTCACGT
CTGACTGGGGCGCCCCTCCCCTTATCCCCCCCCAGCCCGGCTTATAACC
CATGGAAACGGGCCCCCGGGGCCCTAAACCTATACAACTTTTAACAACGG
ATCTCTTGGCTTTCCCATCCATGAAAAAAGCCCCCARWGTGGCGAAACGG
TAATKGGAAATTGSARAATTYMGTAATCMTCSAATCTYTGAACCSCMCTT
GCGYTCCYTGGTATTCCSARGARCMTGCCTGTKWGARTGKCSTGAACTCY
CTCCACYCCSCTTTCTTGTGAARCGGGTTTGGATTTGGAACSCTGGSSG
CTCCGCGCCSCTCGTCTTTAAACSCMTTAGCTGGKCCCTCTGGGYCGGY
CCRASRACGKGTGATAACMAACSCTTTTCSKTGACCGTGGCGSCSCTCST
TWGCMMSGSCCGGGCCSCTTAAMAGTCGTCTTCGGACAACYCTTCWKKTCA
TYTGACCTCAAATCAGGTAGGACTACCCGCTGAACTTAAGCATAWCMATA
AGCSGARGAAAAGAACTAACAAGGATTCCCCTAGTAACGGCGAGTGAAG
CGGGAAGAGCTCAAATTTGTAATCTGGCGGCCTCTGGTCGTCCGARTTGT
AGTCTGGAGAAGCGTTTTCCGCGTCCGACCGTGTACAAGTCCCTTGAAC
```

AGGGCGTCGTAGARGGTGAGAATCCCGTCTTTGACACGGACTGCCGATGC
TTTGCATGCGCTCTCGAAGAGTCGAGTTGTTTGGGAATGCAGCTCAAAA
CGGGTGGTAAATTCCA WCTAAAGCTAAATATTGGCGAAAGACCGATASMS
ARYAASYWYMGTSAGKGAAAGACTTGARARGYACKTACTGACKRWRGAGA
STKARWCAGTMSKTSARAYWGYTGMWWGCKGMAMYRCTKGTAMGTACAT
GATCGCGTCKWMSSKGAYTSWRCMYKGYTAKYTGCKTRGCAGTGATCTATC
SMRSGKTGMSSKGCCAGCRTCRRYTKCGATGCCKTCGGAGAAAGGCCTTG
GGAATGTGGCACCTTCGGGTGTGTTATAGCCCTCGGTCGTATGCGACGGT
TGGGATCGAGGACCGCAGCACGCCTTTTTGGCCGGGGTTTCGCCACGCAC
GTGCTTAGGATGCTGGCGTAATGGCTTTAAGCGACCCGTCTTGAAACACG
GACCAAGGAGTCTAACATGCCTGCGAGTGTGGGGTGGCAAACCCGGACG
CGGAATGAAAGTGAAAGGTTGGGACCTCTGTTCGTGGAGGGCACCGACGCC
CGGACCAGACCTTCTGTGACGGTCCGAGGTAGAGCATGCATGCTGGGAC
CCGAAAGATGGTGA ACTATGCTTGAGTAGGGTGAAGCCAGAGGAAACTCT
GGTGGAGGCTCGTAGCGATTCTGACGTGCAAATCGATCGTCAACTTGAG
TATAGGGGCGAAAGACTAATCGAACCATCTTTGGTTC

AGK 082- *Ramaria sandaracina* Marr and Stuntz

(Plate V, Figure 20)

Basidiocarp:

Habitat - - on soil at base of red oak in deciduous woods (maple, poplar, birch).

Color- -Tangerine orange [more vivid than 4A6-maize yellow (light orange yellow) and 5A6-melon yellow (capucine orange)] branches, and apices. Cream [3A3-pale yellow (cream color)] context and stipe.

Taste- -n/a

Odor- -anise, peppermint?

Form- -basidiocarp medium, up to 8 cm tall by 10.25 cm wide by 7 cm deep, branches 0.8 cm or less, stipe base 1 cm, stipe 1.5 cm. Dichotomous branching, fairly thick branches, apices acute or rounded acute. Branches and apices very crumbly. White basal tomentum on stipe.

Macrochemical Reactions:

Bruising reaction: none apparent.

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: negative

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: 6.32-7.9 x 3.16-3.95, average: 7.03 x 3.28, E value: 2.14, L^m : 7.11, W^m : 3.16, E^m : 2.25, subfusiform with verrucose ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative hyphae clamped.

Collections

Number
AGK 082

Location
Jay Cooke State Park, MN

Date
12 Sept 2010

Distribution: USA- CA, ID, OR, WA

Discussion: The specimen matches *Ramaria sandaracina*, Variety *eosma* is the closest in coloration and shape while var. *sandaracina* has a more appropriate spore range. The species is found in coniferous woods and the specimen was collected in deciduous woods.

> AGK082 Consensus sequence

```
TCTGGAAGGTACTGCGGAGGACATTACAGCATTAGATCGAGGGAGGTTAG
ATGCCGCGCTCGTGAGGGCGCGCGCACCTCTTCTCGTGTCCATTACAC
ACACACCTGTGTAAACCCGGGGGAGACGATGCGCCCGTGACGCGTTTTGC
CCCCTTTCTTATCTCCTTTACACCTCTCCCTGTGACAAAAACACGTGACA
GGCCCCCGGGGCTCAAAAATTTATACAACTTTTTACAACGGATATCTTG
TGTTTTTCATCTATAAAAGAGACCCCGCAAATGCGAAACATAATGTGAAT
TGTGCAAATCTCTGAATCTTCTCATCTTTTAAAACATCTTGCGCTCCTTG
TSATTGCTTYRGAAGRYYRCTSTGYGTSMTGWRTYGARSACYSYCKYKA
SGWCSTAWYCCTTYGWMWMMWKSTYKYGACKRTSGAMASWCGCKGCGSCKST
GYTSGGSGSCSKCTCSTCTCYMACRATTTATSCSGGKCCCCTCKAGGT
CKGTCCSACRACRGTGTGATAACAMACRCTTCKYCKACAGTGTMGCSCT
TCTCSSCASACTCGTGWWMTCGGGGGGSTCKYYYCMTAAWCGAKCGCCGC
RTGTGYCTTCWTGTGYKTTGACCTCAMATCWGGTRGGACWACCCSCCGAA
CWYAARCRTATCWMTAARCGSAGRARAARARACTAWCRAGGATAYCCCCT
WGWMRCCGMGAGWGAAGCGGGAAGAGMTCWMATTTGTAATMTSKCGGCM
TYCGSTCKTSYGAGWTGTAGTCTSKAGAARCGTTTTTCCGYGTSRSASCGT
GYACAWSTCCYTTGGAACAGGGCGTCKYAKAGRGTGAGARTCYCGTCTYT
GACACRGACMGCCSGCGCTYTYGATRCGCTCTCGWAGAGWCKAGTTGTK
TGGGAAWSSAKCTCAWATCGKGTGGTAAATWCCATCTMWAGCTMAATATT
RKMGAAGACCGATAGCGAACACARTACCGTGAGRGAAAGATRARAAGCA
CTYTGGAAAGAGAGTTAAACAKYACGTRAWATTGYTRAAAGGRAAACGCT
TGAAKTSMGTGCGCTCTCCCGGRATWCAGCCTAGMCCCTWAACGCTTGGT
STATTTCCCTGGGACRACGRGCMGCGTCGAWTTCGATCRTCGGAGAAGGG
CCTTTGGGAACGTGRCACCWTCGGGTGTGYTATAGYMCTGGSTCRTATGC
RMMRGTYGATSKATMKMGKACWCKCKKCAMGTCMSTYWWCRRAKRSTCGG
GGTTCGCCACGTTAACGTGCTTAGGACGCTGGCGTAATGGCTTTAAGCG
ACCCGTCTTGAACACGGACCAAGGAGTCTAACATGCCTGCGAGTGTTTG
GGTGGAAAACCCGGACGCGTAACGAAAGTGAAAGGTTGGGACCTCTGTGC
CGGAGGGCACCACGCCCCGGACCAAGAGCTTCTGCGACGGTTCCGAGGCAG
AGCATGCATGCTGGGACCCGAAAGATGGTGAACATATGCCTGGGTAGGGCG
AAGCCAGAGGAAACTCTGGTGGAGGCTCGTAGCGATTCTGACGTGCAAAT
CGATCGTCGAACTTGGGTATAGGGGCGAAAGACTAATCGAACCATCTGTG
GCCTT
```

AGK 067 - *Ramaria sp. 9*

(Plate VI, Figure 21)

Basidiocarp:

Habitat - -on soil in deciduous woods (maple, elm, red oak)

Color- - very light yellowish pink orange [9A2- pinkish white (pale congo pink, pale vinaceous pink), 7A2-pinkish white (light pinkish cinnamon)] branches, lemon yellow [3A5 –light yellow (Baryta yellow)] apices, cream [3A3-pale yellow (cream color)] stipe and context.

Taste- -not distinct

Odor- - fresh fruity

Form- -basidiocarp medium to large, up to 7 cm tall by 8 cm wide by 6.5 cm deep, branches 1 cm wide or less, stipe base 1.5 cm wide or smaller, stipe 3 cm at widest. Polychotomous branching resulting in seemingly chaotic branch clusters, longer branches are very bulbous and overlapping, apices rounded. Upper branches brittle. Large cauliflower clusters with very fine and inconsistent white basal tomentum.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: slow and very light

Melzer's: nonamyloid

Gum Guaiac: positive, blue green

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: (7.11-) 7.9-9.48 (-11.06) x 3.16-3.95, average: 8.31 x 3.84, E value: 2.16, L^m : 7.9, W^m : 3.95, E^m : 2, subfusiform to oblong elliptical with verrucose ornamentation.

Basidia: 4 sterigmata, 3 common, lacking clamps

Hyphae: Generative hyphae lacking clamps, skeletal hyphae

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 067	Nerstrand-Big Woods State Park, Nerstrand, MN	13 Aug 2010
AGK 070	Nerstrand-Big Woods State Park, Nerstrand, MN	13 Aug 2010

Discussion: The specimen does not match any species in subgenus *Laeticolora* (Petersen 1998 unpublished, Exeter 2006). The coloration of the stipe, branches, and apices and the size of the spores make the collection unique. AGK 070 is likely an immature fruit body of the same species, having similar spore size but being a more honey yellow color.

> AGK067 Consensus sequence

GTTCGATGACTAGATTCGTGACTTATGCTACCGACCATCGATCGTCGAGAC
GGGTAGACGTGTGACTGCCTGTCGATGATCGTCCTAGCGTTCGCATCGAT
GCATGCTGACTATCAGTAGATACGCGACTAGCATTTCATAGAGAAGACTAC
AGCATCCTAGTACGCAGAGCGCAGGCTCATGATCGCGTCGTGCGTCGAGT
GAGTCTGAATGCTTCGTGCGACGGTACAGTCCTGACAGCTTGCAGAGTGA
GATTCCGTCTTGACACGACTGCGTGCTTGCATGCGCTCTCGAAGAGTCG
AGTTGTTGGGAATGCAGCTCAAAGCGGTGTAATTCATCTAAAGCTAAA
TATTGCAAAGGCCGATAGCGAACAAGTACCGTGAGGAAAGATGAAAAGCA
ATTTGAAAGAGAAGTAAACCGTTCGTTAAAATGGTGGAAAGGAAACCCCT
GAAGTCCATTCGGTCTTCCCAGGAATCACCTTGTCTTTTTGGGGCTTGG
TGCCTTTTCCGGGGTTGGCGGGCCCGCCTTGATTTTGGCCGTTGGAGAAA
GGGTTTGGGAATGTGGCACCTCCGGGGGGGTTTTTGGCCTTGGTTGTTTG
GGGCGGTGGGGGTTGAGGGTTGCCGGGGGCCTTTTTGGGGCCGGGGTTTG
CCCCGTAACCCCCCTTGGATGGTGGGGTAATGGCCTTTAGCGGCCCGTT
CTGAAACCCGGGCCAGGAATTTAAGGGCCTGCCAAGGTTTGGGGGGCA
AAACCCGGACGCGGAATGAAAGTGAAAGGTTGGGACCTCTGTCGTGGAGG
GCACCGACGCCCGGACCAGACCTTCTGTGACGGTTCGAGGTAGAGCATG
CATGTTGGGACCCGAAAGATGGTGAACATGCCTGAGTAGGGTGAAGCCA
GAGGAACTCTGGTGGAGGCTCGTAGCGATTCTGACGTGCAAATCGATCG
TCGAACTTGGGTATAGGGGCGAAAGACTAATCGAACCAYCTGTGCKMCTG
CGGAGGACATTACAGTATGGTTTAAGGGGGTCCGATGCTGGCCTCTCGCG
AGAGGGGCATGTGCTCGTCCCCGTTTCTAATCTCACATACACCTGTGCAC
CTTATAGGCGAGTGCCCTCCCGTTTGGAGCCGTCGACGGGGTTCGTCGGAC
CGGGGCGCTCCCTCTCTTATTGTACAACAGCAGCCTGTCTTAAACGCATG
TCTTTTCGAAAGCTCTACGGAGCAGACGGTAGCAGTTATAACTTTCAACA
ACGGATCTCTTGGCTTTTGCATCGATGAAGGACGCCGCGAAAGTGCGAAA
CGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTGAACGCATC
TTGCGCTCCTTGGTATTCCGAGGAGCATGCCTGTTTGAAGTGTGTCGTAACG
CCTCCCTCGACTGTTGTCGCTCCTTTGCCGGAGCGGGGTCGGATTTGGAC
GTTTGGCACCCTTCTCTTCCGGAACCTCGGCCAAAACCGCAAAAAGGATG
GGGCCCCATTTTTTCAAACCGGCCAAAATACGGGTGATTCCATAAAC
CATTTTGAAGAGTGGGGTCAATTGGGTTTCAAATGGGTTTCGGCCCCTTC
CCCCCGGGTTTTGTGGGAAAAAGCGTTTTTGGCAAATTTCTCTTCTAAA
TGGAATTTTAGGACCACTT

AGK 068 - *Ramaria* sp. 10

(Plate VI, Figure 22)

Basidiocarp:

Habitat - - on soil in deciduous woods (maple, elm, red oak)

Color- - Light yellowish cream [5A2- orange white (pale cinnamon-pink), 4A2-
yellowish white (pale ochraceous-buff)] branches, lemon yellow [3A5-light yellow

(Baryta yellow)] apices, cream [3A2-yellowish white (light buff)]stipe, cream [3A3-pale yellow (cream color)] context.

Taste- - slightly bitter Odor- - fresh, lightly fruity

Form- - basidiocarp medium to large, up to 10 cm tall by 13 cm wide by 6 cm deep, branches 1.5 cm wide or less, stipe 5 cm wide or less. Polychotomous branching making clusters, branches brittle, apices rounded. Large cauliflower fruiting body, stipe context spongy. Insect chewed on stipe base.

Macrochemical Reactions:

Bruising reaction: none apparent.
Ferric Sulphate: slow positive
Melzer's: nonamyloid
Gum Guaiac: positive, blue green

Microscopic Structures:

Spore print: n/a
Spore: (at 1250 µm) range: 7.11 -8.69 (-9.48) x 3.16-3.95, average: 7.9 x 3.87, E value: 2.04, L^m: 7.9, W^m: 3.95, E^m: 2, subfusiform or oblong-elliptical with verrucose ornamentation.
Basidia: Four sterigmata, unclamped.
Hyphae: Highly branching generative hyphae, unclamped.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 068	Nerstrand-Big Woods State Park, Nerstrand, MN	13 Aug 2010

Discussion: The specimen is morphologically similar to AGK 067 with the exception of a slight pink coloration to the stipe and branches. The ITS sequence does not match anything in GenBank and shows that the collection is not closely related to AGK 067. There is no species match in subgenus *Laeticolora* and the specimen is genetically different enough from AGK 067 to consider it a separate undescribed species.

> AGK068 Consensus sequence

```
CCGGTAGTACTGCGGATGACATTACAGTATGGTTTAAGGGGGTCCGGATGC
TGGCCTCTCGCGAGAGGGGCATGTGCTCGTCCCCGTTTCTAATCTCACAT
ACACCTGTGCACCTTATAGGCGAGCGCCTCCCGTTTGGAGCCGTCCGACG
GGGTCGTCCGACCGGGGCGCTCCCTCTCTTATTGTACAACAGCAGCCTGT
CTTAAACGCATGTCTTTTTGAAAGCTCTACGGAGCAGACGGTAGCAGTTA
TAACTTTCAACAACGGATCTCTTGGCTTTTGCATCGATGAAGGACGCCGC
GAAAGTGCGAAACGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATC
TTTGAACGCATCTTGCCTCCTTGGTATTCCGAGGAGCATGCCTGTTTGA
GTGTCGTGAACGCCTCCCTCGACCGTTGTGCTCCTTTGCCGGAGCGGGG
TCGGATTTGGACGTTTGGACGGTTTCTTTCCGTCGCTCGTCTATAAAT
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GCATTAGCTTGGCCCCCTTTTTTCGAGTCGGTCCGATGACGGTGTGATA
AGAAACGCTTCGTTGACTGTGGCGCCGTTTGGGTCGATTTTGGATCGGGT
CGCTTATAGCCGTCCTTTTGTGTGGACAWASGCGTTTTGCAAATTGTCGTC
TGACCTCAAATSRKGTRGGATCYMCCCCGCCGAAACYTAAKSMTATCAATA
AGMGGAGGAAAAAGAAACWAACCRSSRTTCCCCTTAGTAACGGCGAGKGA
AAGCGGGAAGAGCTCMWATTTGAAMTCKGGCGGTCTGTGGYCGTCCGAGT
TGTAGTSTGGARAAGCGTTTTCCGTGCCGGACCGTGTACRAGTCMCTYGG
AACAGGKCRCTCKCWGAGGGTGWGAMTCCYSWCTTTGACAYRSACTGCCRG
TGCTTTGCGATGYSCTYTCGWMSAGTCGAGTTGTTTGKGAATGYMGCKCM
RAGCGSSYRSYRAATTYSATCTMAAGCTAMATATTSGCAAAMGACCGWYA
SCGMACAAGTASCGTGARGGMAASRTGAWMAGCACTTWSAAASMGWGTK
MAMMAGTMCRTGMAAYTGTYGAWAKGGAAWCGCTKSRAAGTCGASTCGCRT
MWCWSGGGRSTCAGCSTKGKCMTTYTTGCTSKRCTCGRTGMAYWTCMCRG
KGCWCGAMRGSCCRKMRTCGATYKYSMYCSTCCAAGMWAASRCWWWGCA
GGAAKGTAGRMACMWCWRRGYRTKTYWYMGMMMTCSGWCCTAYGMGAC
GGTGCGRATYAGRMTACKSAGYGTCTRCYWTWTGSGRCMKGSGTTCCGCC
ACGTAACGCGCTTAGGATGCTGGCGTAATGGCTTTAAGCGACCCGCTTGA
AACACGGACCAAGGAGTCTAACGTGCCTGCGAGTGTGGGTGCAAACC
CGGACCGGAATGAAAGTGAAAGGTTGGGACCTCTGTTCGTGGAGGGCACC
GACGCCCGGACCAGACCTTCTGTGACGGTCCGAGGTAGAGCATGCATGT
TGGGACCCGAAAGATGGTGAACCTATGCCTGAGTAGGGTGAAGCCAGAGGA
AACTCTGGTGGAGGCTCGTAGCGATTCTGACGTGCAAATCGATCGTTCGAA
CTTGGGTATAGGGGCGAAAGACTAATCGAACCATCTGTGCAC

AGK 071- *Ramaria* sp. 11

(Plate VI, Figure 23)

Basidiocarp:

Habitat - - on soil in grass at base of a white oak in deciduous woods (maple, elm).

Color- - Yellow honey [6A2- orange white (pale pinkish cinnamon), 4A5-butter yellow (buff yellow)] branches, having lighter coloration in upper branches. Cream [3A3-pale yellow (cream color)] context. Dried- branches and stipe [white to 3A3-pale yellow (cream color)] and apices yellow [3A7-genet (primuline yellow)].

Taste- - slightly bitter

Odor- - a bit like citrus

Form- -basidiocarp medium to large, up to 8 cm tall by 12.75 cm wide by 8 cm deep, branches 0.7 cm wide or less, base 3.5 cm wide. Polychotomous branching, mostly rounded branches, many aborted cauliflower branch clusters, apices tri-cuspid.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: light positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 µm) range: (5.53-) 6.62-8.69 (-10.27) x 3.16, average: 7.47 x 3.16, E value: 2.39, Lm: 7.11, Wm: 3.16, Em: 2.25, subfusiform or oblong-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, unclamped.

Hyphae: Generative hyphae lacking clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 071	Nerstrand-Big Woods State Park, Nerstrand, MN	13 Aug 2010

Discussion: AGK 071 is not closely related to any other collection or GenBank species and does not match any subgenus *Laeticolora* species. The coloration of the fruit body and the small spore size makes the collection unique.

> AGK071 Consensus sequence

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GTAGCATTGATGGTTCGATTAGTCTTTCGCCCTATACCCAAGTTCGACG
ATCGATTTGCACGTCAGAATCGCTACGAGCCTCCACCAGAGTTTCCTCTG
GCTTACCCTACTCAGGCATAGTTCACCATCTTTCGGGTCCCAGCATGCA
TGCTCTACCTCGGAACCGTCACAGAAGGTCTGGTCCGGGCGTCGGTGCCC
CCCACGACGGAGGTCCCAACCTTTCATTTCATTCCGCGTCCGGGTTTTTC
CACCCAAACACTCGCAGGCATGTTAGACTCCTTGGTCCGTGTTTCAAGAC
GGGTCGCTTAAAGCCATTACGCCAGCATCCTAAGCACGTTACGTAGGCGA
ACCCCGGCCAAAAGGGCGTGCTGCAATCCTCGATCCCAATCGTCGCATAC
GACCCAGGGCTATAACACACCCAAAGGTGTCACATTCCCAAACCTTTTT
CCGACGGTCAAATCGACGCTGACCCGTCGCCCCAGGAAATACACCAAGC
CACAAAAGCAAGGCTGAATCCCAGGAGACGCGACTGACTTCAAACGTTTC
CCTTTCAACAATTTACGTAAGTGTAACTCTCTTTCCAAAGTGCTTTTC
ATCTTTCCCTCACGGTACTTGTTCGCTATCGGTCTTTCGCCAATATTTAG
CTTTAGATGGAATTTACCACCCGTTTTGAGCTGCATTCCCAAACAACCTCG
ACTCTTTGAGAGCGCATCAAAAGCATCGGCAGTCCGTGTCAAAGACGGG
ATTCTCACCTCTACGACGCCCTGTTCCAAAGGACTTGTACACGGTCCGA
CGCGGAAAACGCTTCTCCAGACTACAACCTCGGGACGACCATAAGCCGCCA
GATTACAAATTTGAGCTCTTCCCCTTCACTCGCCGTTACTAGGGGAATC
CTAGTTTAGTTTCTTTCCCTCCGCTCATTGATATGCTTAAAGTTCAGCGGG
TAGTCCTACCTGATTTGAGGTCAGATGCAAGTCGATCCGGTTAGAAGCTA
ACCTCGTATTAATAATCGAAAAAAAACGGCGCCGACGTACCTATATCACAC
GTCATCTAACCGACTCTAAGCCAGCTGATGCATTAACTACGACGGCAGG
AGACGGTCGCAAGCGTCGAGACCGCCTCCCTCAACAACGAAGAACGAGAA
GAATGAGGAGATCAAACGGATCCTCTCTGGATATCCRCAGCGACKSMGCG
ATGACATTACAGTATTATATAAGACTTGGAGGGACGTGTTGGATGCTGGC
CCGTGAGGGCATGTGCGCGCACGTCTCGAGTATATTACTTACACCTGTGC
ACCTATGGCGAGCGCCTTCCGTTTGGAGCCGTTTGAATGCCAAAACCTT
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TTTGGAGGGGGAGGTGATTAGACCGAGGCGCTCCCTCTTTTCGATTACCA
TTTCGGCCTGTTTGAACGCATGTTATTGAGCTTTATGGGATATGTATAAC
TTTCAACAACGGATCTCTTGGCTTTCGCATCGATGAAGAACGCCGCGAAA
GTGCGAAACGTAATGTGAATTGCAGAATTCAGTGAATCATCGAATCTTTG
AACGCATCTTGGCTCCTTGGTATTCCGAGGAGCATGCCTGTTTGAGTGT
CGTGAATCCTCTCGATCCTCCTCTCTTTGAGGAGGGTGGATTTGGACGC
TTGCGACGGCCCCTGGCCCGTCCCTCGTCTTTAAACCCAGTAGAATGGCC
TGAGGAGCCAGTGAGATGACAGTGTTCCTTTCAACAATTTTCGCGCCCTG
TTAACTCTCTTTCCAAAGAGCGTTTCATCTTTCCCTCACGGTACTTGT
CGCTATCGGTCTTTCGCCAATACTTAGCCTTAGATGGAATCTTACACCCG
TTTTGAGCTGCATTCACAAACAACCTCGACTCCCTGAGAGCGCATCACAAA
GCATCGGAAGTCCGTGTCTAGACAGGAGTCTCACCCCTTACCACGCCCTG
TTCCACAGACTTGTATACTGTCCGACGCGGAAAATGCTTCTTCTGATACA
ACTCGGCGACAGAGGCGGCACATACTAATTTGAGCTCTTCCCGCTTCGTC
TTCGTTACTACGGAAGACTAGTGATTTCTTTGCCTCGCCTCCTTGACATG
CTGAGTCATCGGCGATCGTACTGGATTGGGGTTCGGATGCAAGTCCATCCG
CTAGAGGGAAGCCACGTATTAGATCTGAAAGAAACGGCCCGACCGTACTA
TATTTACCCTCATCGACGAATCCAGCCAGCTATGCCTGAAACCACTTGGC
GGGACGTGGAGCGTGCAGGCACTGGTCTTATCTTGGCAAGGGGATCGGAT
TCGACAGGAGCTGGAATTCCCGACCAAGGCCTCTGTATATTGGGGTATCG

Subgenus *Lentoramaria*

AGK 016 - - *Ramaria cf. gracilis* (Pers.) Quél.

(Plate VI, Figure 24)

Basidiocarp:

Habitat – on soil in deciduous woods (maple and elm)

Color- - Light grey brown [5C- brownish orange (-), 5D3 clay-greyish brown(-)] stipe, branches similar or a buff cream/ yellow brown [4A5- butter yellow (buff yellow)], apices a darker brown [5D7-golden brown (-)], light cream [3A3 pale yellow (cream color)] context.

Taste- - bitter but differing from *R. stricta*

Odor- - slight sweet smell

Form- - basidiocarp medium, up to 6.25 cm tall by 2 cm wide, branches 0.3 to 0.4 cm wide and upper branches 0.1 cm, stipe 0.6 cm wide. Dichotomous branching, very straight upright branches, branches flattened in areas, apices acute or forked. Branches and base have rounded knob-like projections (0.1 cm circumference) that appear to be hyphae covering dirt or rocks. Chalky white basal tomentum on stipe.

Macrochemical Reactions: Bruising reaction: slightly brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 µm) range: (4.74-) 5.93-7.11 x 3.16-3.95 (-4.74), average: 6.27 x 3.80, E value: 1.65, L^m: 6.3, W^m: 3.9, E^m: 1.63, subfusiform or oval with verrucose ornamentation.

Basidia: Four sterigmata, with clamps, readily separating in microscopic mount.

Hyphae: Generative with clamps, mostly skeletal hyphae in apices and stipe

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 016	Pin Oak Prairie Scientific and Natural Area, MN	10 July 2010
AGK 017	Pin Oak Prairie Scientific and Natural Area, MN	10 July 2010
AGK 018	Pin Oak Prairie Scientific and Natural Area, MN	10 July 2010
AGK 024	Forestville State Park, Forestville, MN	11 July 2010
AGK 032	Wild River State Park, MN	24 July 2010
AGK 061	Pin Oak Prairie Scientific and Natural Area, MN	07 Aug 2010
MCBS147	Camden State Park, top of Dakota Valley Trail, MN	29 Aug 2007

Distribution: USA- CA, CT, GA, ID, MI, MN, NJ, NC, NY, OR, SC, TN, VA, VE, WA; Canada- British Columbia, Nova Scotia, Ontario, Quebec; Europe- Czechoslovakia, Denmark, England, France, Holland, Italy, Norway, Poland, Sweden, Switzerland

Discussion: Fruit body is almost entirely skeletal hyphae which may explain the tough texture or the dried specimen. AGK 016 morphologically matches *R. gracilis* but is not genetically close to the species and was found in a deciduous habitat. The ITS sequence has a 96% match with *R. stricta* and a match of 98% with *R. rainierensis*.

> AGK016 Consensus sequence

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CCTGCTAGTACTGCGGACGACATTAACGTATGTTTGAAGGGGTTTGATGC
TGGTCTTCCCACAAAGGGGAGACATTGTGCGCACCCCTCACCTTCTAATC
CCACACACCTTTGTGCACCGTGGTGGTGGCATTGCCACCCCATTCAC
ACACCTATCCCTGTCAATGCATGTCTTGATGGCTCTACGGAGTTATAA
TACATATACAACTTTCAACAACGGATCTCTTGGCTTTCGCATCGATGAAG
AACGCCGCGAAAGCGCGAAACGTAATGTGAATTGCAGAATTCAGTGAATC
ATCGAATCTTTGAACTKYWTCTGKGCCTTCGCWTRGTATTTCCGAAGRA
GCATGGCCTGTTKCRAGKKTCTGAACTCTATCGAMCCMMCTTTCYTCTG
TGATGGTGAGGGTCSGAMTTGGAMCKTYGGCCGCTTCCCMRTCSAMTCS
TCYYCRAATACMTYMRCTGGGGKCYGKSTAMCGGYCSGCYCYCCCKGAY
CAMCGRACGKKGATAARAAAACMCTTGKGSGCCSTCYCMTCYCSRGAR
CCTYCGKTTAAAAARACGAMCTCGYTTCCMATCSTCCTCSGAMMAACTT
TCATGKYATCYGAMCTCCAAWTCAGGWAGGACTACCCSSTKAACCTWARC
MTAWCMATWAGCCGRAGGAAAAGAACTWACCMRGRTTCCCTARTAACG
GGCRAKTRAASC GGARRAGYTCAAATTTGKAATCCTGGCGKYTCAGSC
CKTCSRAGTKGWAKYCWARAGAASCKYCTTCSKTGCCGSCCKKGTMCAA
KTCCCTTGGAACAGGGCGTCATARAGGGTGARAATCCCGTCTTTGRMCG

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GACTGCCGGTGCYCTKTGATGCSCTCTCKMARARTCSAGTTGTTTGGGAA
TGCAGCTCAAACGGGTGGTAAATTCCATCTAAAGCTAAATATTGSCGAA
RGACCGATAGCGAACAAAGTACCGTGAGGGAAAGATGAAAAGCACTTTGGA
AAGAGAGTTAAACAGTACGTGAMATTGTTGAAAGGGWAACGCTTGAAGTC
AGTCGCGTCTYSMSKSACTGMASCTGTCGRYACTCGTSTGMCGSWGYAYY
WYYCGRTSYGACRSGCCAGCAYCKRWYTCRRTMKTMGSAWGMAKGCWCA
GKGAWCTGATTSGCACGCTMYGSGTGTRYWMKASSSCTGRGTCTGKWYRY
GACKKWGGGGATCGAGGATCGCAGCACGCCTTCATTGGCCGGGGTTCGCC
CACGCAACGTGCTTAGGATGCTGGCGTAATGGCTTTAAGCGACCCGTCTT
GAAACACGGACCAAGGAGTCTAACATGCCTGCGAGTGTTTGGGTGGAAAA
CCCGGACGCGGAATGAAAGTGAAAAGTTGGGACCTCTGTCGTGGAGGGCA
CCGACTCCCGGACCAGACCTTCTGTGACGGTTCGAGGTAGAGCATGTAT
GTTGGGACCCGAAAGATGGTGAACATGCCTGAGTAGGGTGAAGCCAGAG
GAAACTCTGGTGGAGGCTCGTAGCGATTCTGACGTGCAAATCGATCGTCG
AACTTGGGTATAGGGGCGAAAGACTAATCGAACCATCAGTGTGCC

AGK 062 - *Ramaria rubella* (Schaeff.) Petersen

(Plate VII, Figure 25)

Basidiocarp:

Habitat – on soil and dead wood in deciduous woods (white oak)

Color- -color lightens from stipe upwards to branches, brown duff [9C3-greyish red (cinnamon drab), 9B3 dull red (light cinnamon drab)] stipe and branches, cream [4A3-cream (capucine buff)] uppermost branches, cream [3A3-pale yellow (cream)] apices and context.

Taste- - very bitter

Odor- - distinct but unknown

Form- -basidiocarp medium to large, 15 cm tall by 6.5 cm wide by 3 cm deep, branches 0.7 cm wide or less, stipe base 3 cm, multiple stipes fused together to make large cluster. Dichotomous branching, very upright pattern, apices biforked acute. Older, dry fruit bodies have grey chalky texture in lower branches. In fresh fruit bodies, context is almost translucent. White basal tomentum on stipe to the point of branching.

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: yellow brown [5A6-melon yellow (capucine orange), 5A7 – (deep chrome)]

Spore: (at 1250 µm) range: 4.74-7.11 x 3.95, average: 6.12 x 3.95, E value: 1.55, L^m:

6.32, W^m: 3.95, E^m: 1.6, subfusiform-oblong with verrucose ornamentation and a rounded peg-like apiculus.

Basidia: Four sterigmata, clamped

Hyphae: Generative hyphae with clamps, clamped supporting hyphae, possible skeletal hyphae.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 062	Pin Oak Prairie Scientific and Natural Area, MN	07 Aug 2010

Distribution: USA- CA, ID, MA, MI, NC, NH, NY, OR, TN, VT WA; Canada- British Columbia, New Brunswick, Nova Scotia, Ontario, Quebec; Europe- Austria, Germany, Switzerland

Discussion: The specimen morphologically matches the description for *R. rubella* but does not appear to be closely genetically related to *R. rubella* f. *rubella*.

> AGK062 Consensus sequence

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GTTGATGGGACTGCGGAGGACATTAACGTATGTTTGAAGGGGTTTGATGC
TGGTCTTCCCACAAAGGGGAAAATTTGGGCCACCCCTCACCTTCAATTC
CCCCCCCCCTTTGGGGCACCGGGGGGGGGGCTTTCCCCCCCCCTTTCCCC
CCCCCTTCCCGGTCCCATGGCTGGTCTGGTGGGTCTCCGGATTTTTAA
AACTTTTCCAATTTTACCACCGAATTTTTGGGTTTTCCCTTCATTAATAA
AACCCCCAAAAGCCCAAACCGTATGGGGAATGGCAAATTCATGGAACC
TTCAATTCTTTAAACCCTTCTGGCCCTCCTGGGATTTCCAAGAACCTGGC
TGGTTTAATGGTCTGGAATTTCTTTCAACCCCTTTTCTTTGGGAAGGGG
AAGGTTCGAATTGGAACTTCGGCSGGCTTSCCSCAGKYSAAATCSKYSSA
AATTACWTCASYGKGGKCTSGTCKAWCGGYCGGYCTCCCTGGATCAMCGA
ACGGGKGGATAARAAACMCTGGKGSSCCSTCCTCWTCTCRARASCYTCWG
TTAARAAARCRACYTCSYTTCCAWTCKYCYTSGAMAAMCTTTCWKGTCWT
YKRACYTCAAWYCAGGWAGGACTACCSGYTGAACCTAARCMTAATCAATA
AGCSGARGAAAAGAAACCTAMCCAGGATTCCCCTAKTAMSGSCRAKTGAA
GCGGGAARASYTCAAWTTKGTAWYCTGGCGKYTCAGGCCKTCCGARTTG
KARTCYAGAGAARCSTCYTYCGTGGCCGGCCCGTGKACMAGTYCCTTGGG
AMCAGGSCGTCATWGARGGKGRGAATYCCGKCYTTGACACGGACTGCCGG
TGCTYTGKGATGCGCTYTCGAAGARTCGAGTTGTTTGGGAATGCAGCTCA
AAACSGGTSMTAATCCATCTMAAGCTAAATATTGGCGAAAGAMCGATA
GCGAACAAGTACCGTGAGGGAAAGATGAAAAGCACTTTGGAAAGAGAGTT
AAACAGWWCGTGAAATTGTYGAAASGGAAACGCTTGAAGTCAGTCGCGTC
TTCCGGGACTCAGCTGRACACTSGTGTCCGGTGTACTTCCCGGTCTGACG
GGCCAGCATYGATTTTCGATCGTCGGAGAAAGGCTCAGGGAACGTGGCACC
TCSKGGWGTGTTATAGCCCTGGGTCGTATGCGACGGTGGGGATCGAGGAT
CGCAGCACGCCTTCATTGGCCGGGGTTCGCCCACGCAACGTGCTTAGGAT
GCTGGCGTAATGGCTTTAAGCGACCCGTCTTGAACACGGACCAAGGAGT
CTAACATGCCTGCGAGTGTGTTGGGTGGAAAACCCGGACGCGGAATGAAAG
TGAAAAGTTGGGACCTCTGTCTGGAGGGCACCGACTCCCGGACCAGACC
TTCTGTGACGGTTCCGAGGTAGAGCATGTATGTTGGGACCCGAAAGATGG
TGAACATGCCTGAGTAGGGTGAAGCCAGAGGAAACTCTGGTGGAGGCTC
GTAGCGATTCTGACGTGCAAATCGATCGTCGAACTTGGGTATAGGGGCGA
AAGACTAATCGAACCATCAAATCCGCT
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AGK 049- - *Ramaria rubella f. rubella* (Schaeff.) R.H. Petersen (Plate VII, Figure 26)

GenBank accession: JQ408236

Basidiocarp:

Habitat – on roots of a white pine and pine stump in mixed woods (maple, white pine, birch)

Color- - Purplish grey [14B3-reddish lilac (purplish lilac)] on base of lower branches, yellow [3A4 pastel yellow (Maize yellow)] apices with perhaps a greenish tint, buff brown cream [4A6-maize yellow (light orange yellow) to 4A5-butter yellow (buff yellow)] stipe, cream [3A3-pale yellow (cream)] context.

Taste- - slightly bitter, tough and rubbery Odor- - distinct but unknown

Form- - basidiocarp small to medium, up to 4.5 cm tall by 3 cm wide by 2 cm deep, branches 0.4 cm wide and less, base (with multiple stipes) 1 cm wide. Polychotomous branching with some flattened branches, apices multi-acute (4 + points). White basal tomentum (marshmallow fluff) up to the point of branching.

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: 6.32 -7.9 x (3.16-) 3.95, average: 7.19 x 3.91, E value: 1.84, L^m : 7.11, W^m : 3.95, E^m : 1.8, subfusiform or oblong-elliptical with verrucose ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative hyphae with clamps, clamped supporting, and skeletal hyphae. Generative hyphae are sometimes very convoluted.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 049	Itasca State Park, MN	26 July 2010

Distribution: USA- CA, ID, MA, MI, NC, NH, NY, OR, TN, VT, WA; Canada- British Columbia, New Brunswick, Nova Scotia, Ontario, Quebec; Europe- Austria, Germany, Switzerland

Discussion: The specimen matches *R. rubella f. rubella* though the rhizomorphs of the collection do not turn pink in KOH as in the species description (Petersen 1975, Exeter

2006). The test was performed on dried material and that may have affected the result of the test.

AGK 010- - *Ramaria stricta* var. *concolor* Corner

(Plate VII, Figure 27)

GenBank accession: JQ408220

Basidiocarp:

Habitat --on rotting wood in deciduous woods (maple, elm)

Color- - fawn brown/tan [4B5-corn (mustard yellow), 4B6- amber yellow (Antimony yellow), 5B5-greyish orange (-), 6B5-greyish orange (cinnamon)] at base, light yellow brown [3A4-pastel yellow (Maize yellow), 3A5-light yellow (Baryta yellow)] branches, and cream tan [4A5-butter yellow (buff-yellow)] apices; cream [3A2-yellowish white (light buff), 3A3-pale yellow (cream)] context.

Taste- - bitter Odor- - earthy

Form- - basidiocarps medium, 8 cm tall by 6 cm wide, stipe 0.5 cm wide, branches 0.1 cm near tip. Dichotomous branching, branches round in cross-section, apices acute. Fluffy white basal tomentum.

Macrochemical Reactions:

Bruising reaction: brunnescent after cutting or handling.

Ferric Sulphate: positive, dark blue-green

Melzer's: nonamyloid.

Gum Guaiac: instant positive

Microscopic Structures:

Spore print- - yellow orange-brown [between 4A7-buttercup yellow (apricot yellow, light cadmium) and 4A6-maize yellow (light orange yellow)].

Spore: (at 1250 μ m) range: (4.92-)5.54-7.38(-8.61) x 3.69(-4.31), average: 6.43 x 3.72, E value: 1.73, L^m:6.15, W^m:3.69, E^m:1.67, subfusiform or oblong elliptical with verrucose ornamentation, large oil droplets. Spores stick together tightly making it challenging to separate them.

Basidia: Four sterigmata, very thin and straight; with clamp connections.

Hyphae: generative with clamps, hyphae with clamps, skeletal hyphae in upper branches.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 010	Versailles State Park, Versailles, IN	26 June 2010
AGK 011	Bernheim Forest, Lexington, KY	27 June 2010
AGK 013	Pin Oak Prairie Scientific and Natural Area, MN	10 July 2010
AGK 014	“	“
AGK 015	“	“

AGK 019
AGK 052

“
Itasca State Park, MN

“
26 July 2010

Distribution: USA- CA, ID, MA, ME, MI, MN, MO, NH, NC, NY, OR, TN, WA, WI;
Canada- British Columbia, Quebec; Europe-Austria, Belgium, Denmark, France,
Germany, Great Britain, Holland, Scandinavia

Discussion: Specimen had a 98% match with *Ramaria stricta*. Though species is *R. stricta* var. *concolor*, specimens seem closely related to *R. rainieriensis* and AGK 078 and AGK 079. Separation may be because of variety differences, which are not clarified on GenBank. There seem to be three distinct *R. stricta* sequence types in Genbank, one of which may not be *R. stricta*.

AGK 044- - *Ramaria stricta* var. *stricta* (Pers.) Quél. (Plate VII, Figure 28)

GenBank accession: JQ408235

Basidiocarp:

Habitat – on rotting wood, deciduous wood (elm, maple)

Color- - fawn brown/tan [4B5-corn (mustard yellow), 4B6- amber yellow (Antimony yellow), 5B5-greyish orange (-), 6B5-greyish orange (cinnamon)] at base, light yellow brown [3A4-pastel yellow (Maize yellow), 3A5-light yellow (Baryta yellow)] branches, and cream tan [4A5-butter yellow (buff-yellow)] apices; cream [3A2-yellowish white (light buff), 3A3-pale yellow (cream)] context.

Taste- - bitter Odor- - anise

Form- - basidiocarps medium to large, up to 11 cm tall by 8.5 cm wide by 3.75 cm deep (with seven stipes joined at the base to form the cluster), branches 0.4 cm wide or less, stipe base 1 cm wide. Dichotomous branching, rounded branches that are very upright forming almost columnar shapes, branches of multiple stipes interweaving to form one massive cluster, apices forked acute. White basal tomentum similar to marshmallow consistency (marshmallow fluff).

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: yellow orange-brown [between 4A7-buttercup yellow (apricot yellow, light cadmium) and 4A6-maize yellow (light orange yellow)].

Spore: (at 1250 μm) range: (5.53-)6.32-7.9 x 3.16-3.95, average: 7.13 x 3.75, E value: 1.90, L^m : 7.11, W^m : 3.95, E^m : 1.8, subfusiform or oblong – elliptical with verrucose ornamentation.

Basidia: Four sterigmata, clamped, tissue not easily separate.

Hyphae: Generative hyphae with clamps, supporting hyphae with clamps, skeletal hyphae

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 044	Itasca State Park, MN	26 July 2010
AGK 045	“	“
AGK 046	“	“

Distribution: USA- CA, ID, MA, ME, MI, MN, MO, NH, NC, NY, OR, TN, WA, WI; Canada- British Columbia, Quebec; Europe-Austria, Belgium, Denmark, France, Germany, Great Britain, Holland, Scandinavia

Discussion: The specimen description matches *R. stricta* var. *stricta*. The distinct anise smell is the best method for distinguishing between *R. stricta* var. *concolor* and *R. stricta* var. *stricta*. Specimens AGK 044, 045, 046 are most closely related to one another but not closely related to the other *R. stricta* var. *concolor* specimens.

AGK 051- - *Ramaria* sp. 5

(Plate VIII, Figure 29)

GenBank accession: JQ408237

Basidiocarp:

Habitat – on decomposing base of living red pine in mixed woods (white pine, maple)

Color- - Mostly concolorous cream buff [4A5-butter yellow (buff yellow) and 4A6 maize yellow (light orange-yellow)] branches, apices, and stipe, lower branches being slightly darker. Cream [3A3-pale yellow (cream)] context.

Taste- - not distinct but not bitter

Odor- - distinct but unknown

Form- - basidiocarp small to medium, 3.75 cm tall by 2.5 cm wide, stipe base 0.3 cm. Dichotomous branching, apices acute. Multiple stipes often fused together at the base.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: negative

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: 3.95-5.53 x 3.16-3.95, average: 5.02 x 3.40, E value: 1.48, L^m : 5.14, W^m : 3.16, E^m : 1.63, subfusiform or oblong-elliptical with verrucose (very pronounced and darkly staining bumps) ornamentation.

Basidia: Four sterigmata, clamped

Hyphae: Generative hyphae with clamps and skeletal hyphae with very thick walls.

Occasionally the walls of the skeletal hyphae are so thick that there is no distinguishable space between them. Some hyphae seem to have oil bubbles, causing a banding pattern in cytoplasm.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 051	Itasca State Park, MN	26 July 2010
AGK 080	Itasca State Park, MN	20 Aug 2010

Discussion: The specimen does not match any known species of subgenus *Lentoramaria* (Petersen 1975) because the collection has a spore range that is significantly smaller than any published species.

AGK 053- - *Ramaria* sp. 6

(Plate VIII, Figure 30)

GenBank accession: JQ408238

Basidiocarp:

Habitat – on leaf and needle duff in mixed woods (red pine, maple)

Color- - Chalky light grey [4A5-butter yellow (buff yellow), 4A6- maize yellow (light orange-yellow)] stipe, branches concolorous or slightly lighter coloration, apices white, cream [3A3-pale yellow (cream)] context.

Taste- - bitter Odor- - popcorn in an unpleasant fashion

Form- - basidiocarp small to medium, up to 7.5 cm tall by 3.75 cm wide by 3 cm deep, branches 0.4 cm wide and less, base of fused stipes 1.6 cm wide. Dichotomous branching with some flattened or wrinkled branches, apices acute. White basal tomentum (marshmallow fluff) to the point of branching. Fruit bodies do not make large mycelial mats.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: yellow brown [5A6-melon yellow (capucine orange), 5A7 – (deep chrome)].

Spore: (at 1250 μm) range: 6.32-7.9 (-8.69) x 3.16, average: 6.74 x 3.16, E value: 2.13, L^m : 6.32, W^m : 3.16, E^m : 2, subfusiform with verrucose ornamentation.
Basidia: Four sterigmata, clamped, hymenium separates easily.
Hyphae: Generative hyphae with clamps

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 053	Itasca State Park, MN	26 July 2010

Discussion: Specimen is morphologically closest to *R. suecica* but has an average spore size that does not fall within *R. suecica*'s range. The ITS sequence of the collection does not match any species in GenBank.

AGK 066- *Ramaria* sp. 8

(Plate VIII, Figure 31)

GenBank accession: JQ408241

Basidiocarp:

Habitat - - on rotting log in mixed woods (white pine and maple)

Color- - Light brown and lighter [4B5-corn (mustard yellow), 4B6-Amber yellow (Antimony yellow), 5B5-greyish orange (-), 6B5- grayish orange (cinnamon), 4A5-butter yellow (buff-yellow)] branches and stipe, apices are slightly lighter than branches, cream [3A3-pale yellow (cream color)] context.

Taste- - bitter

Odor- - not distinct, fresh

Form- -basidiocarp medium, 7.5 cm tall by 4.5 cm wide by 2 cm wide, branches up to 0.5 cm, stipe base 1.25 cm wide. Dichotomous branching, up five tiers, flexible tough branches, apices acute. Cottony basal tomentum on stipe base.

Macrochemical Reactions:

Bruising reaction: slightly brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: orange yellow [5A6 –melon yellow (capucine orange), 5A7 – (deep chrome)]

Spore: (at 1250 μm) range: (6.32-) 7.11 -7.9 x 3.16 – 3.95 (-4.74), average: 7.31 x 3.52, E value: 2.03, L^m : 7.11, W^m : 3.16, E^m : 2.25, subfusiform with verrucose ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative hyphae and supporting hyphae, clamped, and skeletal hyphae (in apices).

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 066	Forestville State Park, MN	08 Aug 2010

Discussion: AGK 066 does not match any known subgenus *Lentoramaria* species. Morphologically the specimen would be the closest to *R. concolor* and *R. stricta*, the former having larger spores and a significantly different E^m value; the latter being morphologically different as well. [*R. concolor* was originally *R. stricta* var. *concolor* but was raised to species level by Petersen but (for some reason) appears to be again considered a variety of *R. stricta* (Petersen 1975).] There are a reasonable number of *R. stricta* sequences in GenBank that should have resulted in a match for the specimen but AGK 066 is not closely related any sequence from the species.

AGK 073- *Ramaria* sp. 12

(Plate IX, Figure 32, 33)

GenBank accession: JQ408244

Basidiocarp:

Habitat - - on rotting branches (coniferous wood) under leaf layer in mixed woods (white pine, maple, red oak).

Color- - Young fruit bodies a very light yellow cream [4A4-light yellow (cream buff, pale orange-yellow)] branches and apices, branches darkening to a medium purplish brown [7B5-greyish red (pinkish cinnamon) to 8D6-reddish brown (-) to 9E5-reddish brown (-) to 12F6-dark ruby (dusky brown)] with age, bruising, or being in a humid container. Apices almost a banding pattern: brown purple branches with yellow cream-brown band and grey white tips. Context cream [3A3-pale yellow (cream color)] with a tiny hint of yellow.

Taste- -slightly bitter

Odor- -strong but not distinct

Form- -basidiocarp small to medium, up to 8.5 cm tall by 4 cm wide by 1 cm deep, branches 0.5 cm wide or less, base 1 cm wide or less. Dichotomous branching, branches round, apices acute. Fluffy white basal tomentum on stipe.

Macrochemical Reactions:

Bruising reaction: brunnescent to vivescent [13F8- dark Magenta (dusky dull violet)

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: orange [5A7- (deep chrome), 4A6-maize yellow (light orange yellow)].

Spore: (at 1250 μm) range: 7.11-7.9 x (3.16-) 3.95-4.74, average: 7.51 x 3.95, E value: 1.90, L^m : 7.51, W^m : 3.95, E^m : 1.90, subfusiform with verrucose (small bumps but densely covered) ornamentation.

Basidia: 4 sterigmata, clamped, hymenium does not come apart easily.

Hyphae: Generative hyphae and supporting hyphae with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 073	U of M Cedar Creek ESR, MN	15 Aug 2010

Discussion: Specimens were placed into a plastic container with lid for approximately two hours during collection trip. Drastic brown-purple color change may be the result of bruising but every surface, including internal branch axils, changed. It is likely a reaction to a humid and warm condition inside the container. It should be noted that no other collections of *Ramaria* were affected by being in similar conditions. The specimen does not key to any current species and the ITS sequence does not match to a species. The combination of color of the stipe, branches, and apices, as well as the overall color shift from yellow when young to purple-brown when old, makes the specimens distinctly different than anything in subgenus *Lentoramaria* or *Laeticolora*.

AGK 076- *Ramaria* sp. 13

(Plate IX, Figure 34)

GenBank accession: JQ408245

Basidiocarp:

Habitat - - on leaf and pine duff in mixed woods (red oak, white pine)

Color- - Cinnamon brown [7D8-burnt sienna (vinaceous-rufous)] stipe and lower branches becoming lighter in upper branches [5D8-yellowish brown (raw sienna)], cream [3A3-pale yellow (cream color)] context.

Taste- -slightly bitter

Odor- -not distinct

Form- -basidiocarp small to medium, up to 8 cm tall by 6 cm wide by 2 cm, branches 0.4 cm wide or less, base 0.7 cm wide and less. Dichotomous branching, apices acute or rounded. Yellowish basal tomentum on stipe until the point of branching and mycelial mat.

Macrochemical Reactions:

Bruising reaction: slightly brunnescent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 µm) range: (4.74-) 5.53-7.11 x 3.16-3.95, average: 5.87 x 3.72, E value: 1.58, L^m: 5.53, W^m: 3.95, E^m: 1.4, subfusiform with tuberculate-nodulose (large round pustules) ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative clamped hyphae.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 076	U of M Cedar Creek ESR, MN	15 Aug 2010

Discussion: In a small area, hundreds of fruiting bodies formed in trails around the base of white pines. The specimens do not match any current species of *Ramaria* in subgenus *Lentoramaria* or *Laeticolora* and the ITS sequence does not result in any close match. The tuberculate-nodulose ornamentation of the spores makes the specimen unique among the other AGK collections. The color of the fruit bodies may be lighter in younger and fresher samples but the overall description would not be altered.

AGK 081- *Ramaria* sp. 14

(Plate IX, Figure 35)

GenBank accession: JQ408246

Basidiocarp:

Habitat - - on needle and pine duff in mixed woods (elm, red pine)

Color- - light cream buff [4B5-corn (mustard yellow), 4B6-Amber yellow (Antimony yellow), 4A5-butter yellow (buff yellow)] branches and apices with lighter cream in upper most branches, cream [3A3-pale yellow (cream color)] context.

Taste- - n/a

Odor- - almost nutty, earthy

Form- -basidiocarp medium, 7.5 cm tall by 7.25 cm wide by 4 cm deep, branches up to 0.4 cm, stipe up to 1.75 cm wide. Dichotomous with short internodes, making it look polychotomous, branches mostly rounded in cross section, apices acute. ‘Marshmallow fluff’ basal tomentum on stipe into lower branches. Mycelial mat holds leaf duff tightly and to immediate bottom of FB. fruit body very flexible and rubbery but not heavy. Young fruit bodies have almost broccoli-like look with many tipped apices.

Macrochemical Reactions:

Bruising reaction: brunnescent

Ferric Sulphate: positive

Melzer’s: negative

Gum Guaiac: positive

Microscopic Structures:

Spore print: n/a

Spore: (at 1250 μm) range: 3.95-4.74 (-5.53) x 2.37-3.16, average: 4.38 x 2.84, E value: 1.54, L^m : 4.35, W^m : 3.16, E^m : 1.38, subfusiform with verrucose ornamentation.

Basidia: Four sterigmata, clamped.

Hyphae: Generative hyphae with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 081	Itasca State Park, MN	20 Aug 2010

Discussion: There is no subgenus *Lentoramaria* or *Laeticolora* species that matches the specimen: the small spore size of the collection makes it unique (Corner 1950, Marr & Stuntz 1973, Petersen 1975, Hansen et al. 1997, Exeter 2006).

Subgenus *Echinoramaria*

AGK 020- - *Ramaria* sp. 2

(Plate X, Figure 36)

GenBank accession: JQ408224

Basidiocarp:

Habitat – on soil amongst grass/sedge, in deciduous woods (maple, white oak)

Color- - Light pink/purple [13B2-purplish grey (pale purple vinaceous), 14B3 reddish lilac (purplish lilac) branches and apices, stipe of similar coloration with light ochreous brown [4A7- buttercup yellow (apricot yellow, light cadmium), 5A7 (deep chrome)] spore deposits, white or light cream [3A3- pale yellow (cream color)] context.

Taste- - bitter, metallic Odor- - surprising lack of scent

Form- - basidiocarp medium, up to 7.75 cm tall by 4.5 cm wide by 3 cm deep, branches 0.55 wide, thick chunky stipe up to 3 cm wide. Polychotomous branching with thick round branches that are very flexible and rubbery, apices cuspid. Spore deposits give stipe a powdery texture. Context tissue very sponge-like and absorptive. Insect or herbivore chewed on base of stipe.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: positive

Melzer's: nonamyloid

Gum Guaiac: positive but slow and with a green coloration

Microscopic Structures:

Spore print: light ochreous brown [4A7- buttercup yellow (apricot yellow, light cadmium), 5A7 (deep chrome)]

Spore: (at 1250 μm) range: (9.48-)10.3-11.85 x 4.74-5.53 (-6.32), average: 11.09 x 5.10, E value: 2.17, L^m : 11.1, W^m : 4.74, E^m : 2.34, oval (long and slender) with striations (ridges that run vertically but not in a regular striate fashion).

Basidia: Four sterigmata, with clamps, basidia often very chubby with oil droplets, sterigmata with distinct spaces (oil droplets?) making sterigmata look empty.

Hyphae: Generative hyphae with clamps

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 020	Forestville State Park, Forestville, MN	10 July 2010

Discussion: This specimen is not morphologically close to any species with the purple tint to branches. Specimen is close to AGK 023 and AGK 064 and *R. cystidiophora*. The morphology of this specimen does not match *R. cystidiophora*, mainly the lack of purplish pink coloration in that species.

AGK 023- - *Ramaria* sp. 3

(Plate X, Figure 37)

GenBank accession: JQ408225

Basidiocarp:

Habitat – on soil in deciduous woods (basswood, white oak [swamp], maple)

Color- - Pale skin tone cream [6A3-pale orange (pinkish buff)] branches and apices, base cream white [3A2-yellowish white (light buff)] with light orange yellow [5A6-melon yellow (capucine orange)] spore deposits, cream [3A3 pale yellow (cream color)] context.

Taste- - bitter Odor- - fresh clean smell, almost light floral; maple syrup when dry

Form- - basidiocarp medium, up to 9.5 cm tall by 6.5 cm wide by 5 cm tall, often fused stipes up to 12 cm wide, branches 0.5 to 0.1 cm wide, stipe 3.75 cm wide. Polychotomous branching with short stout branches mostly on upper two-thirds of fruiting body, acute apices. Very stout base with slight white felt-like tomentum on base, stipes fuse to form large clusters. Stipe is very tough and rubbery but branches are brittle and break easily.

Macrochemical Reactions:

Bruising reaction: none apparent

Ferric Sulphate: positive but slow

Melzer's: nonamyloid

Gum Guaiac: positive

Microscopic Structures:

Spore Print: light orange yellow [5A6-melon yellow (capucine orange)]

Spore: (at 1250 μm) range: (8.69-) 9.48 (-10.27) x (3.95-) 4.74 (-5.53), average: 9.44 x 4.62, E value: 2.03, L^m : 9.48, W^m : 4.74, E^m : 2, oblong-elliptical or oval with striate (ridges that run vertically but not in a regular striate fashion) ornamentation.

Basidia: Four sterigmata, with clamps.

Hyphae: Generative hyphae with clamps.

Collections

<u>Number</u>	<u>Location</u>	<u>Date</u>
AGK 023	Forestville State Park, Forestville, MN	11 July 2010
AGK 064	“	08 Aug 2010

Discussion: Specimen is morphologically close to *R. rubripermanens* but the spores sizes of the collection are on average smaller and do not fit within the range for the species. Specimen is not genetically closely related to *R. rubripermanens* but is close to AGK 020 and *R. cystidiophora*. Though both AGK 020 and AGK 023 look similar and seem closely related, the spore measurements of the two collections are different enough to suggest they are two distinct species. The morphology of this specimen does not match *R.cystidiophora* (having striate spores and overall appearance).

Appendix 2: Taxonomic Key for *Ramaria* in Minnesota

Appendix 2.1 Key to Species by Subgenera

Key to Subgenera

- 1A. Substrate lignicolous or humicolous..... 2
- 1B. Substrate terricolous..... 3

- 2A(1).Spore ornamentation echinulate (spines..... *Echinoramaria*
- 2B. Spore ornamentation verrucose (bumps/warts) or tuberculate-nodulose (large rounded bumps).....*Lentoramaria*

- 3A(1).Spore ornamentation striate.....*Ramaria*
- 3B. Spore ornamentation echinulate, verrucose, or tuberculate-nodulose.....*Laeticolora*

Key to *Echinoramaria*

- 1A. Substrate on the soil..... 3
- 1B. Substrate leaf or pine needle duff or rotting wood.....2

- 2A. Substrate on rotting wood..... 4
- 2B. Substrate leaf or pine needle duff.....
-*Ramaria myceliosa* (AGK 035, MCBS153, MCBS266)

- 3A(1).Type of branching single, near tip; branches flattened, either entirely or somewhat; apices cuspid; bruising reaction none.....*Ramaria cf. eumorpha* (AGK 008)

- 3B. Type of branching dichotomous; branches rounded; apices acute, multi-acute, forked, pointed or tri-pointed; bruising reaction brunnescent.....
..... **Ramaria sp. 4 (AGK 033, 37, 38)**
- 4A(2).Bruising reaction none; branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow; spore deposit n/a..... 5
- 4B. Bruising reaction brunnescent; branches darker brown, cinnamon brown, or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown colorations; spore deposit orange yellow, ochre yellow.....
..... **Ramaria sp. 7 (AGK 063)**
- 5A(4).Hyphae monomitic: generative.....**Ramaria argentea (AGK 027, 36, 42)**
- 5B Hyphae dimitic-pseudodimitic: generative and supporting.....
.....**Ramaria sp. 1 (AGK 012)**

Key to *Laeticolora*

- 1A. Apices cuspid..... 3
- 1B. Apices rounded, acute, multi-acute, forked, pointed or tri-pointed..... 2
- 2A(1). Apices rounded.....4
- 2B. Apices acute, multi-acute, forked, pointed or tri-pointed..... 12
- 3A(1).Branches light yellow, honey yellow; type of branching polychotomous; branches rounded; bruising reaction none..... **Ramaria sp. 11 (AGK 071)**
- 3B. Branches cream, buff, or other light brown colorations; type of branching dichotomous; branches flattened, either entirely or somewhat; bruising reaction brunnescent.....**Ramaria cf. acrisiccescens (AGK 077, DJM1629)**
- 4A(2).Hyphae monomitic: generative.....6
- 4B. Hyphae dimitic.....5
- 5A(4). Hyphae dimitic-skeletal: generative and skeletal.....**Ramaria sp. 9 (AGK 067)**
- 5B. Hyphae dimitic-pseudodimitic: generative and supporting.....**Ramaria cf. celerivirescens (AGK 072)**
- 6A(4). Gum guaiac positive (blue-black)..... 8
- 6B. Gum guaiac negative or undetermined.....7
- 7A(6).Gum guaiac negative (no reaction).....**Ramaria sandaracina (AGK 082)**
- 7B. Gum guaiac n/a or undetermined.....**Ramaria cyaneigranosa (DJM1628)**
- 8A(6).Type of branching polychotomous..... 9
- 8B. Type of branching dichotomous..... 11

- 9A(8).Branches having apricot or other orange colorations; bruising reaction
brunnescent; stipe light yellow brown, light brown buff, tan
.....**Ramaria flavigelatinosa cf. var. carnisalmonea (AGK 075)**
- 9B. Branches cream, tan, yellow, or brown coloration; bruising reaction none; stipe
cream, yellow cream, buff cream, white, grey.....10
- 10A(9).Branches light yellow, honey yellow; apices being differently colored than
branches or stipe; basidial clamp connection absent; clamp connection in
generative hyphae absent.....**Ramaria sp.10 (AGK 068)**
- 10B. Branches cream, buff, or other light brown colorations; apices being concolorous
with branches or stipe OR being either slightly lighter or darker than branches
or stipe in coloration; basidial clamp connection present; clamp connection in
generative hyphae present**Ramaria rasilisporoides (AGK 069)**
- 11A(8).Stipe light yellow brown, light brown buff, tan; bruising reaction brunnescent;
branches light yellow brown, light brown buff, fawn brown, tan, light grey
brown; habitat mixed woods: pine, maple, oak, birch etc.....
.....**Ramaria foetida (AGK 058)**
- 11B. Stipe cream, yellow cream, buff cream, white, grey; bruising reaction none;
branches cream, cream yellow or buff cream; habitat deciduous woods: oak,
maple, elm, aspen, birch, or basswood.....
..... **Ramaria flavobrunnescens var. aromatica (AGK 059)**
- 12A(2). Gum guaiac positive (blue-black)..... 14
- 12B. Gum negative or
undetermined..... 13
- 13A(12) Gum guaiac n/a or undetermined..... **Ramaria cf. longispora (DJM1507)**
- 13B. Gum guaiac negative (no reaction) **Ramaria sandaracina (AGK 082)**
- 14A(12).Type of branching Polychotomous..... 15
- 14B. Type of branching dichotomous..... 16
- 15A(14).Bruising reaction none; branches cream, tan, yellow, or brown coloration; stipe
brown, tan, cream, white, or yellow colorations; spore deposit n/a.....
.....**Ramaria flavigelatinosa (AGK 028, 83)**
- 15B. Bruising reaction brunnescent; branches having apricot or other orange
colorations; stipe apricot, light orange cream, orange; spore deposit orange
yellow, ochre yellow
.....**Ramaria aurea (AGK 025)**
- 16A(14).Branches light yellow, honey yellow; stipe honey yellow or mainly yellow
colorations; spore tuberculate-nodulose (large round nodules).....
.....**Ramaria pusilla (AGK 057)**
- 16B. Branches cream, buff, or other light brown colorations; stipe cream, white, buff,
or other light brown colorations; spore verrucose (bumps or ridges)..... 17

- 17A(16). Branches light yellow brown, light brown buff, fawn brown, tan, light grey brown; stipe light yellow brown, light brown buff, tan; bruising reaction brunnescent; spore deposit n/a.....
***Ramaria rubricarnata var. pallida* (AGK 078)**
- 17B. Branches cream, cream yellow, or buff cream; stipe cream, yellow cream, buff cream, white, grey; bruising reaction none; spore deposit orange yellow, ochre yellow.....***Ramaria cf. rubiginosa* (AGK 056I)**

Key to *Lentoramaria*

- 1A. Hyphae monomitic: generative.....4
 1B. Hyphae dimitic or trimitic..... 2
- 2A(1). Hyphae dimitic..... 3
 2B. Hyphae trimitic: generative, supporting, and skeletal.....8
- 3A(2). Hyphae dimitic-skeletal: generative and skeletal.....6
 3B. Hyphae dimitic-pseudodimitic: generative and supporting.....
***Ramaria sp. 12* (AGK073)**
- 4A(1). Branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow; spore verrucose (bumps or ridges).....5
 4B. Branches darker brown, cinnamon brown, or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown colorations; spore tuberculate-nodulose (large round nodules).....***Ramaria sp. 13* (AGK 076, 48)**
- 5A(4). Spore deposit orange yellow, ochre yellow; apices being differently colored than branches or stipe; stipe cream, yellow cream, buff cream, white, grey; branches flattened, either entirely or somewhat.....***Ramaria sp. 6* (AGK 053)**
 5B. Spore deposit n/a; apices being concolorous with branches or stipe OR being either slightly lighter or darker than branches or stipe in coloration; stipe light yellow brown, light brown buff, tan; branches rounded.....
***Ramaria sp. 14* (AGK 081)**
- 6A(1). Branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow; substrate on rotting wood..... 7
 6B. Branches darker brown, cinnamon brown, or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown colorations; substrate on the soil ..***Ramaria cf. gracilis* (AGK 016, 17, 18, 19, 24, 32, 61, MCBS147)**
- 7A(6). Habitat deciduous woods: oak, maple, elm, aspen, birch, or basswood; apices being differently colored than branches or stipe; stipe light yellow brown, light brown buff, tan; spore deposit orange yellow, ochre yellow
***Ramaria stricta var. concolor* (AGK 010, 11, 13, 14, 15, 19, 52)**

- 7B. Habitat mixed woods: pine, maple, oak, birch etc; apices being concolorous with branches or stipe OR being either slightly lighter or darker than branches or stipe in coloration; stipe cream, yellow cream, buff cream, white, grey; spore deposit n/a ***Ramaria sp. 5* (AGK 051, 80)**
- 8A(2). Habitat deciduous woods: oak, maple, elm, aspen, birch, or basswood..... 9
- 8B. Habitat mixed woods: pine, maple, oak, birch etc..... 10
- 9A(8). Branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow..... ***Ramaria stricta var. stricta* (AGK 044, 45, 46)**
- 9B. Branches darker brown, cinnamon brown or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown coloration ***Ramaria rubella* (AGK 062)**
- 10A(8). Branches mostly brown, tan, cream, white, yellow, or orange in coloration; type of branching dichotomous; spore deposit orange yellow, ochre yellow..... ***Ramaria sp. 8* (AGK 066)**
- 10B. Branches mostly purple, pink, or red in coloration; type of branching polychotomous; spore deposit n/a..... ***Ramaria rubella f. rubella* (AGK 049)**

Key to subgenus *Ramaria*

- 1A. Branches Light pink-purple; Stipe Purple, light purple or pink; Apices cuspid..... ***Ramaria sp. 2* (AGK 020)**
- 1B. Branches Light pink (skin tone); Stipe Brown, tan, cream, white, grey, yellow, or orange colorations; Apices acute, multi-acute, forked, pointed or tri-pointed..... ***Ramaria sp. 3* (AGK 023)**

Appendix 2.2 Key to *Ramaria* Species

- 1A. Spore smooth (no ornamentation)..... 5
- 1B. Spore ornamented (verrucose, echinulate, striate, etc.)..... 2
- 2A(1). Spores verrucose (bumps or ridges) or tuberculate-nodulose (large round nodules)..... 3
- 2B. Spores echinulate (spines) or striate..... 4
- 3A(2).Spore verrucose.....7
- 3B. Spore tuberculate-nodulose..... 33
- 4A(3). Spore echinulate.....34
- 4B. Spore striate..... 39

5A(1). Branches mostly brown, tan, cream, white, yellow, or orange in coloration; stipe brown, tan, cream, white, grey, yellow, or orange colorations; type of branching dichotomous.....	6
5B. Branches mostly purple, pink, or red in coloration; stipe purple, light purple or pink; type of branching Polychotomous..... <i>Clavulina cinerea</i> (AGK 022, 26, 41, 43)	
6A(5). Bruising reaction none; gum guaiac n/a or undetermined; substrate on the soil; basidial clamp connection absent.....	<i>Clavulina sp.</i> (AGK 009)
6B. Bruising reaction brunnescent; gum guaiac positive (blue-black); substrate leaf or pine needle duff; basidial clamp connection present..... <i>Lentaria byssiseda</i> (AGK 034, 39, 40)	
7A(3). Hyphae monomitic: generative.....	10
7B. Hyphae dimitic or trimitic.....	8
8A(7).Hyphae trimitic: generative, supporting, and skeletal.....	30
8B. Hyphae dimitic.....	9
9A(8). Hyphae dimitic-skeletal: generative and skeletal.....	25
9B. Hyphae dimitic-pseudodimitic: generative and supporting.....	29
10A(7).Apices rounded, acute, multi-acute, forked, point.....	11
10B. Apices cuspid.....	<i>Ramaria sp.</i> 11 (AGK 071)
11A(10).Apices rounded.....	12
11B. Apices acute, multi-acute, forked, pointed or tri-pointed.....	18
12A(11).Gum guaiac positive (blue-black).....	14
12B. Gum guaiac negative or undetermined.....	13
13A(12).Gum guaiac n/a or undetermined.....	<i>Ramaria cyaneigranosa</i> (DJM1628)
13B. Gum guaiac negative (no reaction).....	<i>Ramaria sandaracina</i> (AGK 082)
14A(12).Type of branching polychotomous.....	15
14B. Type of branching dichotomous.....	17
15A(14).Bruising reaction none; stipe cream, yellow cream, buff cream, white, grey; branches cream, tan, yellow, or brown coloration.....	16
15B. Bruising reaction brunnescent; stipe light yellow brown, light brown buff, tan; branches having apricot or other orange colorations..... <i>Ramaria flavigelatinosa</i> cf. <i>var. carnisalmonea</i> (AGK 075)	
16A(16).Branches light yellow, honey yellow; basidial clamp connection absent; clamp connection in generative hyphae absent; apices being differently colored than branches or stipe.....	<i>Ramaria sp.</i> 10 (AGK 068)

- 16B. Branches cream, buff, or other light brown colorations; basidial clamp connection present; clamp connection in generative hyphae present; apices being concolorous with branches or stipe OR being either slightly lighter or darker than branches or stipe in coloration.....***Ramaria rasilisporoides* (AGK 069)**
- 17A(14).Stipe light yellow brown, light brown buff, tan; bruising reaction brunnescent; basidial clamp connection absent; habitat mixed woods: pine, maple, oak, birch etc.....***Ramaria foetida* (AGK 058)**
- 17B. Stipe cream, yellow cream, buff cream, white, grey; bruising reaction none; basidial clamp connection present; habitat deciduous woods: oak, maple, elm, aspen, birch, or basswood.....***Ramaria flavobrunnescens var. aromatica* (AGK 059)**
- 18A(11).Basidial clamp connection absent; clamp connection in generative hyphae absent..... 19
- 18B. Basidial clamp connection present; clamp connection in generative hyphae present..... 22
- 19A(18).Branches having apricot or other orange colorations.....20
- 19B. Branches cream, tan, yellow, or brown colorations..... 21
- 20A(19).Type of branching polychotomous; bruising reaction brunnescent; gum guaiac positive (blue-black); spore deposit orange yellow, ochre yellow.....***Ramaria aurea* (AGK 025)**
- 20B. Type of branching dichotomous; bruising reaction none; gum guaiac n/a or undetermined; spore deposit n/a..... ***Ramaria cf. longispora* (DJM1507)**
- 21A(19).Stipe light yellow brown, light brown buff, tan; type of branching polychotomous; spore deposit n/a; branches light yellow brown, light brown buff, fawn brown, tan, light grey brown.....***Ramaria flavigelatinosa* (AGK 028, 83)**
- 21B. Stipe cream, yellow cream, buff cream, white, grey; type of branching dichotomous; spore deposit orange yellow, ochre yellow; branches cream, cream yellow, or buff cream.....***Ramaria cf. rubiginosa* (AGK 056I)**
- 22A(18).Stipe light yellow brown, light brown buff, tan; bruising reaction brunnescent.... 23
- 22B. Stipe cream, yellow cream, buff cream, white, grey; bruising reaction none.... 24
- 23A(22).Substrate on the soil; habitat deciduous woods: oak, maple, elm, aspen, birch, or basswood; Melzer's (context) amyloid (blue-black).....***Ramaria rubricarnata var. pallida* (AGK 078)**
- 23B. Substrate leaf or pine needle duff; habitat mixed woods: pine, maple, oak, birch etc; Melzer's (context) nonamyloid (no reaction).... ***Ramaria sp. 14* (AGK 081)**
- 24A(22).Branches having apricot or other orange colorations; branches rounded; gum guaiac negative; Spore deposit n/a.....***Ramaria sandaracina* (AGK 082)**

- 24B. Branches cream, tan, yellow, or brown coloration; branches flattened, either entirely or somewhat; gum guaiac positive (blue-black); spore deposit orange yellow, ochre yellow.....**Ramaria sp. 6 (AGK 053)**
- 25A(9).Apices rounded, acute, multi-acute, forked, pointed.....26
- 25B. Apices cuspid.....**Ramaria cf. acrisiccescens (AGK 077, DJM1629)**
- 26A(25).Apices rounded..... **Ramaria sp. 9 (AGK 067)**
- 26B. Apices acute, multi-acute, forked, pointed or tri-pointed..... 27
- 27A(26).Branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow; substrate on rotting wood..... 28
- 27B. Branches darker brown, cinnamon brown, or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown colorations; substrate on the soil.....**Ramaria cf. gracilis (AGK016, 17, 18, 19, 24, 32, 61, MCBS147)**
- 28A(27).Branches light yellow brown, light brown buff, fawn brown, tan, light grey brown; stipe light yellow brown, light brown buff, tan; bruising reaction brunnescent; gum guaiac positive (blue-black).....
..... **Ramaria stricta var. concolor (AGK010, 11, 13, 14, 15, 19, 52)**
- 28B. Branches cream, cream yellow, or buff cream; stipe cream, yellow cream, buff cream, white, grey; bruising reaction none; gum guaiac negative.....
.....**Ramaria sp. 5 (AGK 051, 80)**
- 29A(9).Apices rounded; substrate on the soil; habitat deciduous woods: oak, maple, elm, aspen, birch, or basswood; branches cream, buff, or other light brown colorations.....**Ramaria cf. celerivirescens (AGK 072)**
- 29B. Apices acute, multi-acute, forked, pointed or tri-pointed; substrate on rotting wood; habitat mixed woods: pine, maple, oak, birch etc; branches light yellow, honey yellow..... **Ramaria sp. 12 (AGK 073)**
- 30A(8).Habitat deciduous woods: oak, maple, elm, aspen, birch, or basswood.....31
- 30B. Habitat mixed woods: pine, maple, oak, birch etc..... 32
- 31A(20).Branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow.....**Ramaria stricta var. stricta (AGK 044, 45, 46)**
- 31B. Branches darker brown, cinnamon brown, or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown coloration.....
..... **Ramaria rubella (AGK 062)**
- 32A(30).Type of branching polychotomous; spore deposit n/a; branches mostly purple, pink, or red in coloration.....**Ramaria rubella f. rubella (AGK 049)**
- 32B. Type of branching dichotomous; spore deposit orange yellow, ochre yellow; branches mostly brown, tan, cream, white, yellow, or orange in coloration.....
.....**Ramaria sp. 8 (AGK 066)**

- 33A(3). Habitat deciduous woods: oak, maple, elm, aspen, birch, or basswood; branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow; substrate on the soil..... ***Ramaria pusilla* (AGK 057)**
- 33B. Habitat mixed woods: pine, maple, oak, birch etc; branches darker brown, cinnamon brown, or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown colorations; substrate leaf or pine needle duff.....***Ramaria sp. 13* (AGK 076,48)**
- 34A(4).Substrate on the soil..... 36
- 34B. Substrate leaf or pine needle duff or rotting wood..... 35
- 35A(34).Substrate leaf or pine needle duff.....
.....***Ramaria myceliosa* (AGK 035, MCBS153, MCBS266)**
- 35B. Substrate on rotting wood..... 37
- 36A(34).Type of branching single, near tip; apices cuspid; branches flattened, either entirely or somewhat; bruising reaction none.....
.....***Ramaria cf. eumorpha* (AGK 008)**
- 36B. Type of branching dichotomous; apices acute, multi-acute, forked, pointed or tri-pointed; branches rounded; bruising reaction brunnescent
.....***Ramaria sp. 4* (AGK 033, 37, 38)**
- 37A(35).Branches buff, tan, cream, yellow brown or other yellow colorations; stipe buff, tan, cream, white, yellow; bruising reaction none; spore deposit n/a..... 38
- 37B. Branches darker brown, cinnamon brown, or other brown colorations; stipe darker brown, cinnamon brown, or other medium brown colorations; bruising reaction brunnescent; spore deposit orange yellow, ochre yellow.....
.....***Ramaria sp. 7* (AGK 063)**
- 38A(37).Hyphae monomitic: generative.....***Ramaria argentea* (AGK 027,36,42)**
- 38B Hyphae dimitic-pseudodimitic: generative and supporting.....
..... ***Ramaria sp. 1* (AGK 012)**
- 39A(4). Stipe purple, light purple or pink; branches light pink-purple; apices cuspid.....
.....***Ramaria sp. 2* (AGK 020)**
- 39B. Stipe brown, tan, cream, white, grey, yellow, or orange colorations; branches light pink (skin tone); apices acute, multi-acute, forked, pointed or tri-pointed.....
.....***Ramaria sp. 3* (AG K023)**

Plate I
Species of Subgenus *Echinoramaria*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
1. <i>Ramaria argentea</i>	AGK 027	X 1/2
2. <i>Ramaria myceliosa</i>	AGK 035	X 1/2
3. <i>Ramaria sp.</i> 1	AGK 012	X 1/4
4. <i>Ramaria sp.</i> 4	AGK 038	X 1/2



Plate II

Species of Subgenus *Echinoramaria*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
5. <i>Ramaria sp.</i> 7	AGK 063	X 1/3

Species of Subgenus *Laeticolora*

6. <i>Ramaria acrisiccescens</i>	DJM1629	X 1/3
7. <i>Ramaria cf. acrisiccescens</i>	AGK 077	X 1/6
8. <i>Ramaria aurea</i>	AGK 025	X 1/2



Plate III

Species of Subgenus *Laeticolora*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
9. <i>Ramaria</i> cf. <i>celerivirescens</i>	AGK 072	X 1/5
10. <i>Ramaria cyaneigranosa</i>	DJM1628	X 1/2
11. <i>Ramaria flavigelatinosa</i>	AGK 083	X 1/4
12. <i>Ramaria flavigelatinosa</i> cf. var. <i>carnisalmonea</i>	AGK 075	X 1/2



Plate IV

Species of Subgenus *Laeticolora*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
13. <i>Ramaria flavobrunnescens</i> var. <i>aromatica</i>	AGK 059	X 1/4
14. <i>Ramaria foetida</i>	AGK 058	X 1/5
15. <i>Ramaria</i> cf. <i>longispora</i>	DJM1507	X 1/2
16. <i>Ramaria pusilla</i>	AGK 057	X 1/3



Plate V

Species of Subgenus *Laeticolora*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
17. <i>Ramaria</i> cf. <i>rasilisporoides</i>	AGK 069	X 1/5
18. <i>Ramaria</i> cf. <i>rubiginosa</i>	AGK 056I	X 1/4
19. <i>Ramaria rubricarnata</i> var. <i>pallida</i>	AGK 078	X 1/5
20. <i>Ramaria sandaracina</i>	AGK 082	X 1/4



17



18



19



20

Plate VI

Species of Subgenus *Laeticolora*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
21. <i>Ramaria sp.</i> 9	AGK 067	X 1/4
22. <i>Ramaria sp.</i> 10	AGK 068	X 1/5
23. <i>Ramaria sp.</i> 11	AGK 071	X 1/4

Species of Subgenus *Lentoramaria*

24. <i>Ramaria gracilis</i>	AGK 016	X 1/6
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Plate VII

Species of Subgenus *Lentoramaria*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
25. <i>Ramaria rubella</i>	AGK 062	X 1/5
26. <i>Ramaria rubella</i> f. <i>rubella</i>	AGK 049	X 1/5
27. <i>Ramaria stricta</i> var. <i>concolor</i>	AGK 011	X 1/3
28. <i>Ramaria stricta</i> var. <i>stricta</i>	AGK 044	X 1/5



Plate VIII

Species of Subgenus *Lentoramaria*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
29. <i>Ramaria</i> sp. 5	AGK 051	X 1/4
30. <i>Ramaria</i> sp. 6	AGK 053	X 1/5
31. <i>Ramaria</i> sp. 8	AGK 066	X 1/4



Plate IX

Species of Subgenus *Lentoramaria*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
32. <i>Ramaria sp.</i> 12	AGK 073	X 1/8
33. <i>Ramaria sp.</i> 12	AGK 073	X 1/8
34. <i>Ramaria sp.</i> 13	AGK 076	X 1/8
35. <i>Ramaria sp.</i> 14	AGK 081	X 1/5



Plate X

Species of Subgenus *Ramaria*

<u>Figure</u>	<u>Collection</u>	<u>Magnification</u>
36. <i>Ramaria</i> sp. 2	AGK 020	X 1/7
37. <i>Ramaria</i> sp. 3	AGK 023	X 1/4

